This Month's Cover: Drive for analytical centrifuge having speeds up to 70,000 rpm. Designed and built by Specialized Instruments Corp., this drive is discussed in "Precision Speed Control," Page 102.

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MACHINE DESIGN

Vol. 22—No. 9 **September, 1950**

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

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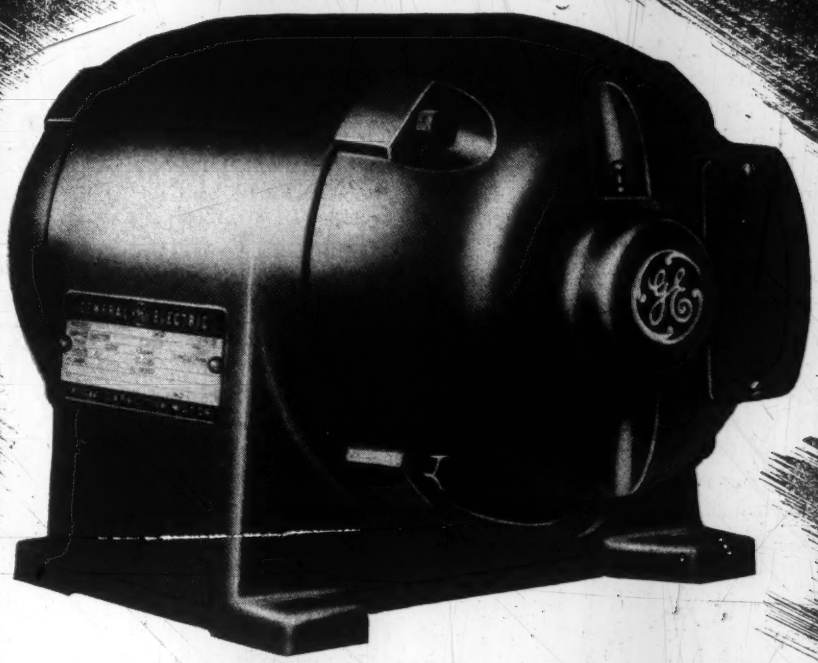

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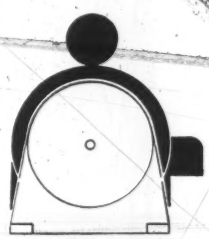

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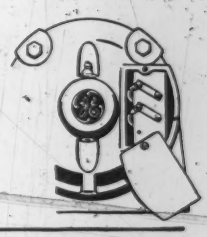

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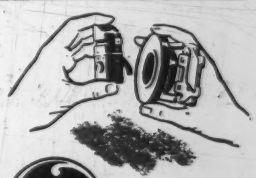

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GENERAL ELECTRIC 754-3

SINGLE-PHASE
CAPACITOR MOTORS 1 to 5 hp

TOPICS

MAGNETIC STEEL ALLOY is being rolled to a thickness of 0.00025-inch in Armco Steel Corporation's Research Laboratory. Used in high-frequency electronic equipment, the thin strip is rolled from stock 0.002 to 0.006-inch thick in a special mill having rolls only 5/16-inch in diameter. Razor blades in a jig are used to slit the strip preparatory to testing.

PLATE AND SHEET, as designations applied to aluminum, have been standardized in meaning by the Aluminum Association. "*Plate* is a solid section rolled to a thickness of 0.250-inch and heavier, in rectangular form with either sheared or sawed edges. *Sheet* is a solid section rolled to a thickness range of 0.006 to 0.249-inch inclusive, supplied with sheared, slit or sawed edges. *Flat Sheet* is furnished in rectangular form with sheared, slit or sawed edges . . . *Coiled Sheet* is furnished in rolls (coils) with slit edges."

SINGLE CRYSTALS of copper, zinc, lead, cadmium, and other metals are being nurtured from seed to a size approximately 9 inches long by ¼-inch in diameter by scientists at Carnegie Institute of Technology. These large single crystals are being used in exhaustive investigations of the basic mechanism governing the plastic deformation of metals.

ORIENTED SILICON lamination for transformer stacks gives higher permeability with lower core loss. Announced by Thomas and Skinner Steel Products Co., the oriented silicon material permits reduced transformer stacks or increased efficiency.

HARD COATING OF ALUMINUM for scratch and wear resistance is being performed by Glenn L. Martin Company. Designated as "MHC" finish, the new coating opens the way for use of aluminum in many aircraft applications previously restricted to heavier steel alloys. It is applied to aluminum and aluminum alloys of less than 5 per cent copper by an electrochemical process which creates a nonmetallic, file-hard, heat-refractive surface. The coating may be from 0.0001 to 0.006-inch thick, abrasion-resistant uses, as a rule, calling for 0.002-inch. Coatings have been applied successfully to such dissimilar items as gears, pinions, surveying instrument parts, turbine impeller blades, hand tools, swivel joints, leading edges of high-speed airfoils, cams, and leg braces for paraplegics.

TANTALUM CAPACITORS with a shelf life of 5 to 8 years and operable in temperatures from −60 to 200 C have been developed for replacement of electrolytic types.

COLOR FILM can be processed and printed by a new technique in a fraction of the time formerly required. Developed by Ansco for special USAF requirements, the new method involves a prehardener which permits processing at 80 F instead of 68 to 70 F as required in ordinary color work. Reducing the delay between the time pictures are taken by photo airplanes and the time they are ready for inspection, the new method is expected to be generally used for photo-reconnaisance work. Color photos are preferred because they are much better than black-and-white for camouflage detection and general interpretation.

SAFETY PLATE GLASS introduced by Buick reduces sun glare and also the amount of heat which enters an automobile through windows. Having a slight blue-green tint, the new glass excludes at least half the radiant heat that penetrates regular glass and shuts out a large portion of the suns ultraviolet rays.

SEAMLESS ALUMINUM SHEATHING for telephone and electric-power cables is being produced by a new method developed by Alcoa. Processed by cold reduction or swaging, the new sheathing weighs about one-eighth as much as the usual lead sheathing.

INDUCTION HEAT TREATING of nonferrous metal strip by a new technique was recently announced by R. M. Baker of Westinghouse. Called "transverse flux induction treating," the method is claimed to be practical and economical for the continuous treatment of such materials as aluminum, brass, copper, magnesium, and stainless steel which are not susceptible to conventional radio-frequency induction heating.

SEPTEMBER, 1950

MACHINE DESIGN
A PENTON PUBLICATION

Isolationism Has No Place in Design

DISCERNING readers who have followed recent articles on cam design must have been struck by a curious fact. For many years textbooks and handbooks have recommended cam profiles that give the follower either "gravity" or "harmonic" motion. At the same time other textbooks, and other pages of the same handbooks, stressed the importance of the suddenly applied load effect which produces elastic stresses and deformations twice as great as does the same load gradually applied.

The peculiar point is that the recommended cam profiles result in suddenly applied inertia loads when the action is intermittent. Yet for years, generations even, so few engineers tumbled to an obvious relationship between two well-known facts that cams are still being designed largely according to the old rules. Only the increasing severity of the suddenly applied load effect as machine speeds have increased in recent years has forced engineers to analyze this cam problem with due regard to mass and elasticity effects.

Here is an extreme example of what might be called isolationism in design. Because the textbooks discussing suddenly applied load effects did not actually mention cam design, designers seem to have assumed that this factor was of no consequence in the design of cams.

A tendency to ignore information not specifically labeled as applying to the problem at hand is still somewhat prevalent. There is no longer any excuse for such an attitude. By cutting across the machinery field from capital goods to domestic appliances, MACHINE DESIGN provides the medium of exchange of information, ideas and design techniques among engineers in all the different branches. Taking advantage of this fund of know-how the wide-awake designer learns how the other fellow goes about his job, his imagination is fired, and his effectiveness is vastly increased by the stimulation. He has ceased to be an isolationist.

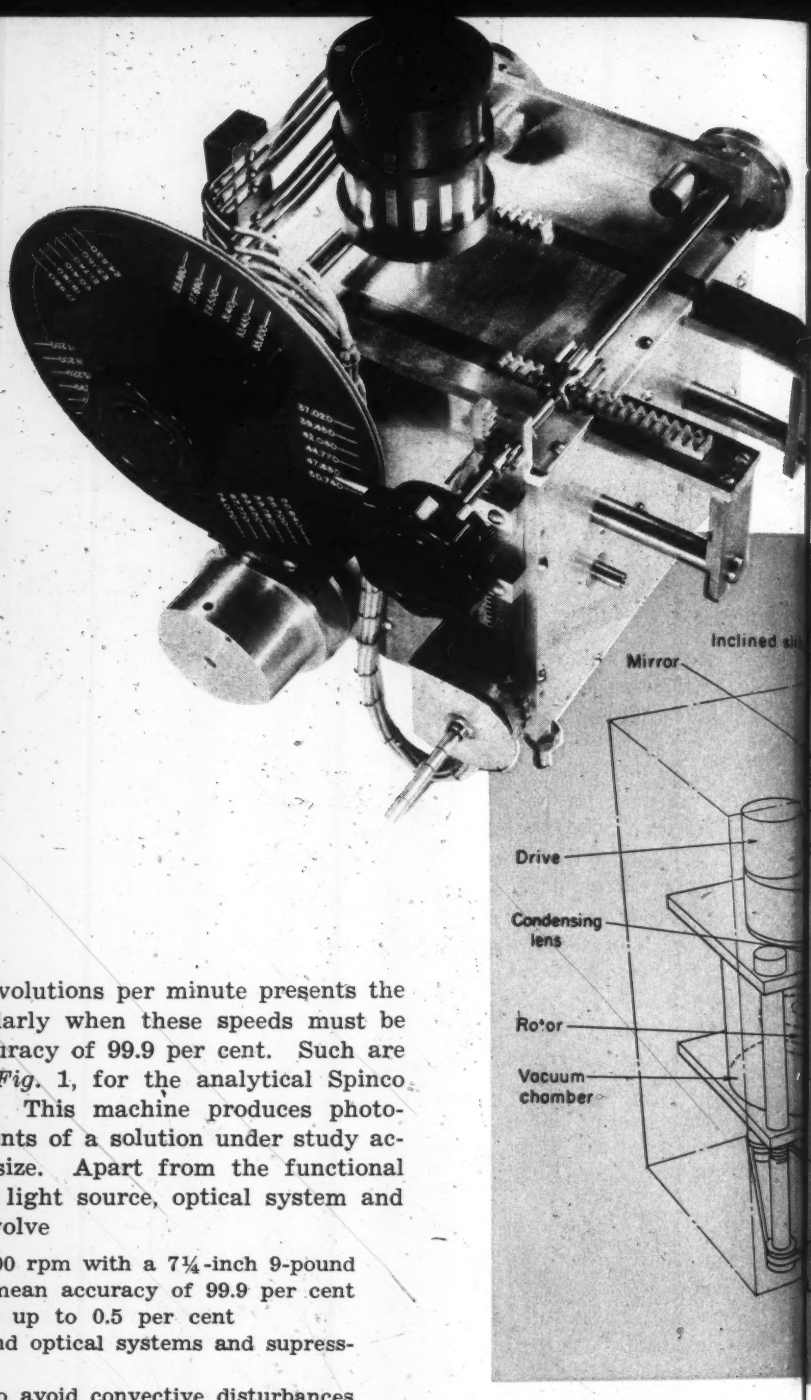
Colin Carmichael

EDITOR

By E. G. Pickels
Director of Research
Specialized Instruments Corp.
Belmont, Calif.

Precision Speed Control

. . . in centrifuge maintains drive accuracy of 99.9 per cent



ATTAINMENT of speeds up to 70,000 revolutions per minute presents the designer with many problems, particularly when these speeds must be controlled automatically within an accuracy of 99.9 per cent. Such are the requirements of the speed-control unit, *Fig.* 1, for the analytical Spinco ultracentrifuge illustrated in *Figs.* 2 and 3. This machine produces photo-diagrams to classify macromolecular constituents of a solution under study according to sedimentation rate and particle size. Apart from the functional requirements inherent in the arrangement of light source, optical system and automatic camera the principal problems involve

1. Producing speeds between 60,000 and 70,000 rpm with a 7¼-inch 9-pound rotor and controlling the set speed at a mean accuracy of 99.9 per cent while permitting instantaneous deviations up to 0.5 per cent
2. Isolating vibrations between mechanical and optical systems and supressing noise
3. Reducing frictional heating on the rotor to avoid convective disturbances and controlling rotor temperature at several different values
4. Measuring rotor temperature within a few tenths of a degree centigrade for calculations to determine the viscosity of the solution under study
5. Minimizing vibration and abuse of mechanical parts through a self-balancing arrangement that permits the rotor to seek its natural axis of gyration and yet not wobble or precess so as to interfere with optical resoluion.

An overall schematic concept of the ultracentrifuge is presented in *Fig.* 2. The solution under study is held in a transparent cell within a rotor which spins within an evacuated chamber. By virtue of refractive index gradients introduced in the fluid through the sedimentation of dissolved material, light rays directed through the revolving cell and a special optical system register patterns on a photographic plate from which the sedimentation rates and concentrations of the various components can be measured.

Further detail may be seen in the photograph of a partially assembled machine, *Fig.* 4. The evacuating system connects with the stationary 1-inch lid of the rotor chamber through a 3½-inch elbow of steel piping. This chamber is opened, closed and automatically locked through the action of three large threaded rods driven together with a chain by an electric motor and reduction gearing. To insure even seating of the movable section against the rubber sealing gasket set into the stationary lid of the vacuum chamber, the three rods rest on spring mounts. For physical protection, the rotor chamber is composed of 1-inch steel end plates, a 10-inch section of 16-inch steel tubing with ½-inch wall, and an inner, freely disposed 2-inch thick cylinder of centrifugally-cast armor steel. In the event of rotor breakage or escape, this liner is able to rotate and absorb tangential inertia as well as the radial shock. Within the guard ring there is a thin-walled cylinder to which are attached cooling coils that connect through

flexible leads to the refrigerator.

The 7¼-inch analytical rotor is illustrated in *Fig.* 5. It is machined from a solid forged billet of duralumin and given the oval shape to increase the speed rating. Two vertical holes are arranged to hold the sample cell and its counterbalance, parts which are shown at the right. The threaded stem and centering boss engage with the coupling device. Although the rotor is capable of withstanding over 70,000 rpm, its routine operating speed is limited to 60,000. At this speed it imparts to the specimen a mean centrifugal force of 260,000 times gravity.

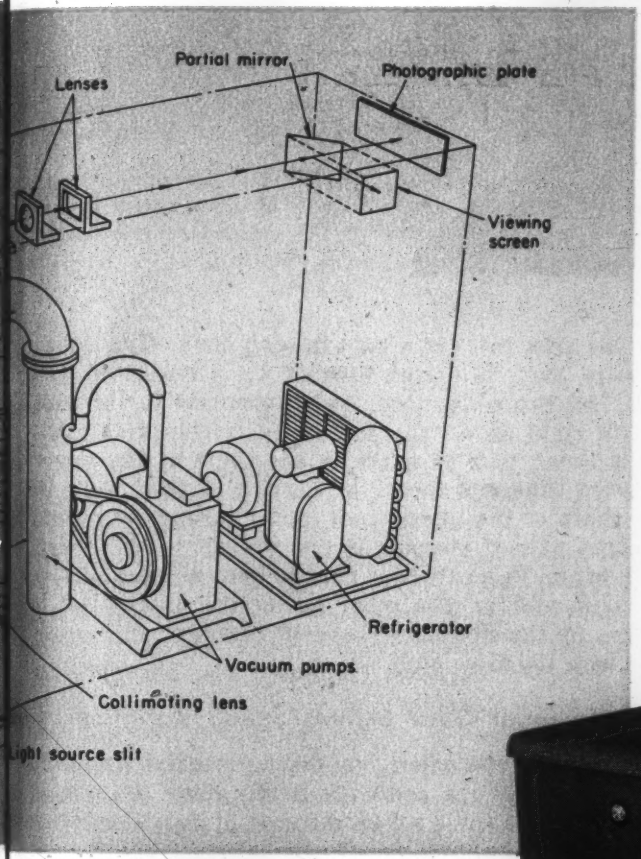


Fig. 1—Top — Exterior of ultracentrifuge speed control. Desired speed is set by combination of speed-range knob, left, and specific-speed knob, right. Other controls regulate camera operation

Fig. 2—Above—Schematic drawing of ultracentrifuge showing the relation of the major components in the machine

Fig. 3—Right — Analytical ultracentrifuge capable of producing forces 260,000 times gravity in a fluid specimen and simultaneously photographing the distribution of sedimentation boundaries

ELECTRIC DRIVE: Illustrated in cross section in *Fig.* 6 is the heart of the machine. The electric drive-motor is mounted on top of a cylindrical gear housing below which the high-speed output shaft projects to a coupling device to which various types of rotors can be attached.

Rated at 12,000 rpm, the 115-volt motor is water and air-cooled, has series-wound universal brush type construction and develops 1½ hp. Cooling water passes around the shell and to the lower bearing of the gear housing through copper tubing. With a gear ratio 5⅓ to 1, the large nonmetallic gear on the motor shaft drives a steel gear on the 5/16-inch high-speed spindle to which the output shaft is attached. This spindle is guided by three large spring-loaded ball-bearing rollers whose peripheries bear on the spindle at points 120 degrees apart.

Pinned at the lower end of the spindle, the flexible 1/10-inch piano-wire driveshaft passes through two babbitt-lined bearings which seal against vacuum, and terminates in a screw-type coupling which accommodates and centers with a projecting boss on the top of the rotor. Approximately 1½ inches of unsupported shaft between the lower of these bearings and the coupling permits flexing of the shaft in operation and serves to make the rotor self balancing to the extent that precision weighing of opposing rotor loads for balance is not required, and inadvertent leakage of fluid from the rotor cell causes no harm, Critical speed of the system is less than 1000 rpm, well below the operating range.

A stationary support fork of steel serves the double purpose of facilitating installation of the rotor by providing a rest during the time when the coupling is being tightened and acting as a safety device to catch the rotor in the event of shaft failure. Since

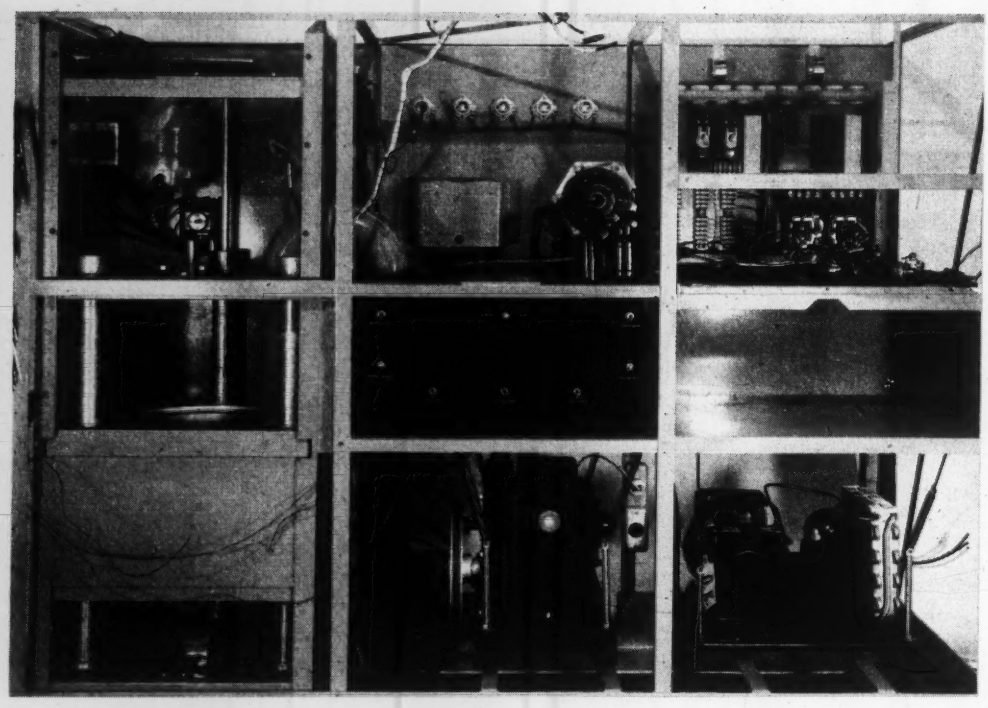


Fig. 4 — Partially assembled machine. Drive fits into compartment at upper left and rotor in armored chamber below. Speed-control unit fits into upper central section and connects to drive and synchronous motor at right in the section. Vacuum pumps and refrigerator are at bottom

the rotor chamber is operated under vacuum, the output-shaft bearing-assembly also acts as a sealing unit. The one or two cubic centimeters of oil per hour which do escape are thrown into a catcher and then drain through a tube into a collector.

Below the main nonmetallic gear is a double-reduction system of worm gears driven by the motor shaft with 400 to 1 ratio. This drives an output shaft connected with and providing reference speed to a separate speed-control unit. Spur gearing on the same takeoff shaft supplies the drive for an electric tachometer which turns at 2000 rpm for 60,000-rpm rotor speed.

The complete driving assembly is resiliently supported on rubber mountings attached to a subbase bolted to the 1-inch armor-steel floor of the drive compartment. It is shown in operating position in *Fig.* 7 and removed from the housing and inverted in *Fig.* 8. In routine use, this drive accelerates the standard analytical rotor to 60,000 rpm in 7 minutes when the motor current is kept at 15 amperes. Braking to rest is accomplished in approximately the same time by reversing the armature connections of the motor and connecting to the 115-volt supply through current-limiting resistors. Various braking rates are obtained by selecting resistance values. Constant-speed operation at 60,000 rpm requires only about 400 watts input to overcome losses in the drive, the frictional resistance on the rotor being very small.

SPEED CONTROL: Speed requirements of 99.9 per cent mean accuracy are desired to permit accurate calculation of the average centrifugal field imposed upon the specimen during the period of study. This, of course, means a permissible variation of only 60 rpm when running at 60,000 rpm. Control action is provided by the gearbox illustrated in *Figs.* 9 and 1.

The speed-selecting portion of the speed control unit consists essentially of two double banks of gears connected in series, there being provision for selecting one gear ratio at a time in each bank. The lower, forward bank is driven directly by a low-speed (10 rpm) synchronous motor which connects to the unit on its right side. The motion is conveyed through the selected pair of gears to the shaft of the upper forward bank and thence by gearing of fixed ratio to the shaft of the upper, rear bank; through a second selected pair of gears it is transmitted to the lower, rear bank. From there it goes to one side of a differential assembly. The other leg of the differential is driven by the slow-speed take-off described in connection with the drive unit.

Differential Gear Signals Speed Variations

When the two inputs to the differential assembly are turning at the same speed, the rotor is rotating at exactly the speed set on the control dials associated with the gear shifting mechanism of the control unit, assuming the frequency of the power supply to be accurate. Any discrepancy between these speeds causes a displacement of the third gear in the differential assembly—one direction for overspeed, the opposite for a drop from the chosen speed. Precision limit switches mounted on the outside left of the gearbox are actuated in response to these differential motions by the vertical movements of a block about its neutral position. Total vertical movement of the block is limited to $\frac{3}{8}$ inch and when it rides against its stops, as during acceleration and deceleration of the ultracentrifuge, excessive torsional loading on either the drive or the speed control is prevented by a slip-clutch situated between the gear banks and the differential assembly.

The switches apply or remove fixed amounts of resistance in the power circuit to the drive motor and cause it to accelerate or decelerate as required to maintain nominal speed. These automatic adjustments tend to counteract such variables as fluctuations in line voltage, motor efficiency, etc. And since

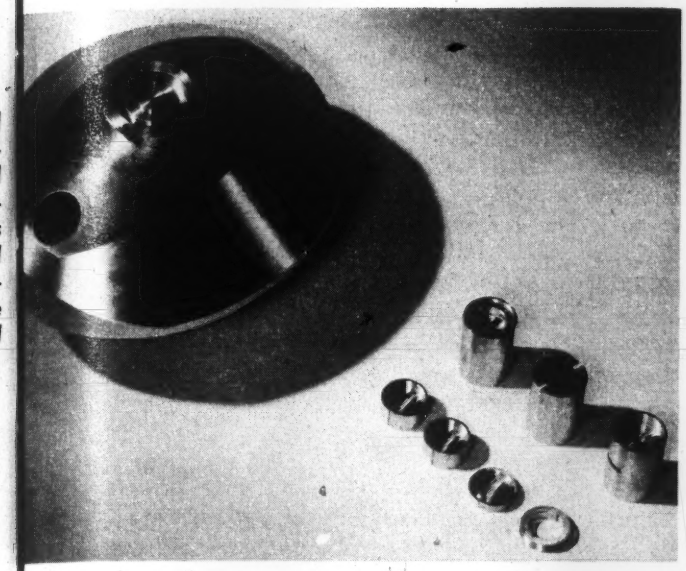


Fig. 5—Analytical rotor. Cell for fluid specimen has transparent quartz windows and is held in one of two vertical holes. Counterbalance fits the other. Light projects upward through cell during run

the action is always to return the differential gear to its neutral position, the control is exact in that the total revolutions from the two inputs must always be identical to within the small displacements experienced by the differential gear. Hunting about the nominal speed is very slow and limited to a few tenths of one per cent by the high inertia of the system and by the imposition of a "wiggle motion" on the input from the drive that compensates for all mechanical backlashes in the system. The output shaft from the drive, while parallel to the input shaft of the speed control, is offset from its axis by several inches, and the universal joints transmitting the motion to and from the intermediate shaft are oriented sufficiently out of parallel with respect to each other to give the desired wiggle motion.

Gear shifting is accomplished by two knobs located on the control panel. Each actuates a rack and pinion which translates a shaft through an upper bank of floating gears meshed with nonfloating gears in the bank immediately below. Only one floating gear is engaged at a time by the sliding shaft and shifting may be done while the machine is in operation. The left-hand knob operates the rear bank of gears, selecting one of five speed ranges and indicating this choice to the operator by turning a large disk so the selected group of speeds appears in a window in the panel. The right-hand knob actuates the front bank of gears, selecting one specific speed from the group and indicating it with a red pointer which moves vertically, driven by an auxiliary rack and pinion on the front of the control unit. Thirty speed settings ranging from 12,000 rpm to 74,000 rpm are available.

A nominal operating voltage corresponding to the selected speed is obtained through manual adjustment of a variable transformer. The control system is ordinarily set to accommodate variations of about ±7 per cent and a series of three indicator lights on

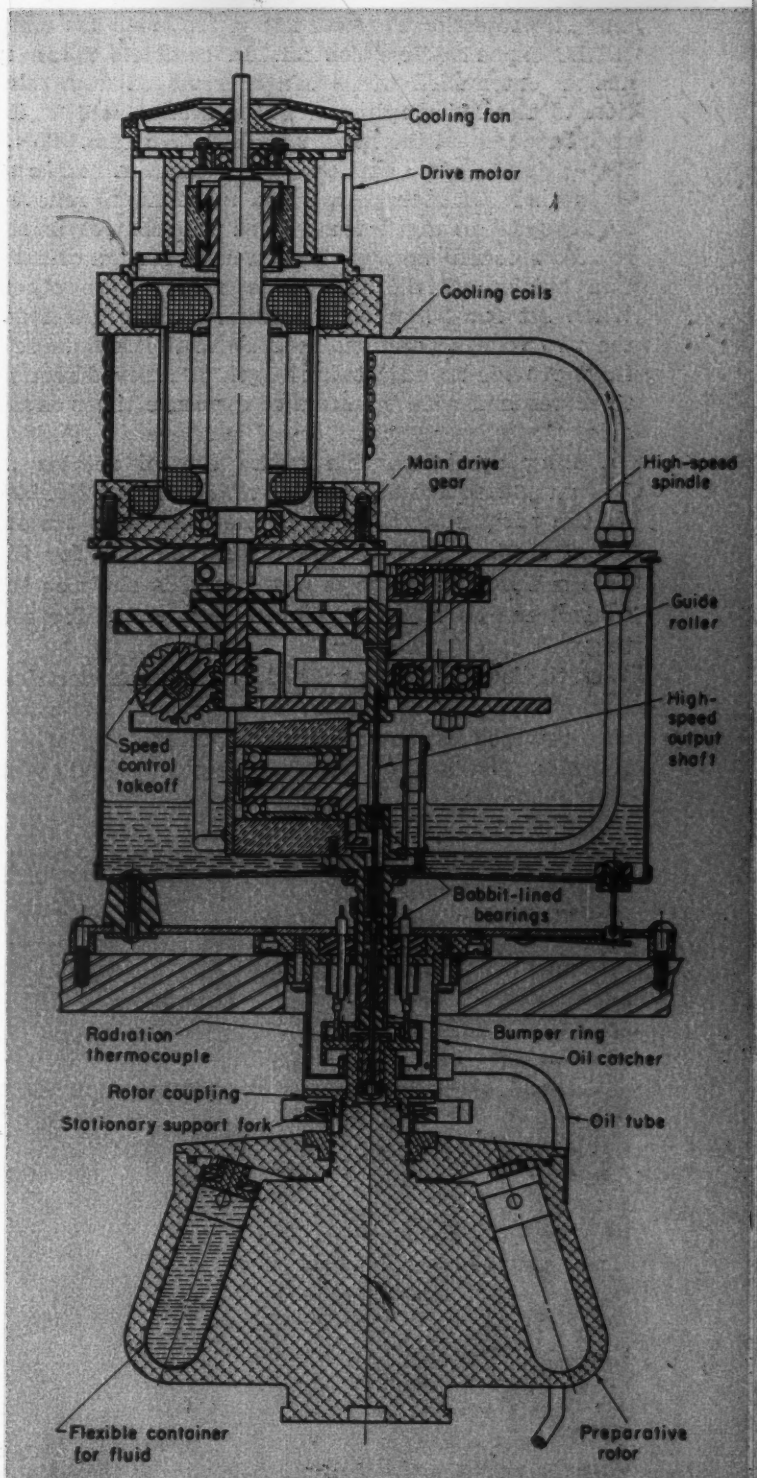


Fig. 6—Section through electromechanical drive of centrifuge. Preparative rotor illustrated is interchangeable with analytical rotor shown in Fig. 4. Tube for light passage through drive is not shown

the panel show whether it is—at a given moment—on speed, accelerating or decelerating.

Additional functions of the control unit include timing and actuating the automatic camera. Referring to *Fig.* 1, the two knobs under the speed-setting controls govern camera operation. The cyl-

indrical projection at lower left is the basic assembly of the exposure-time control. In complete form, it has an outer shell which can be revolved with relation to the inner cylinder. Each section has at its rear edge behind the panel a disk-shaped cam. These center on the same axis and lie in adjacent planes to each other. On their peripheries are identical relieved sections so arranged that, when the control is set to zero seconds exposure time, a solid section of each cam blanks off the relieved section of the other. When set for 30 seconds maximum exposure time, the two relieved sections coincide. Intermediate settings provide an adjustable length of relieved section to correspond with the scale of exposure times available.

During operation, this entire control rotates at ½ rpm and an actuating roller of a limit switch rides on the periphery. Descent of the roller into the relieved section actuates the camera shutter for the time set. A slip-clutch is fitted on this shaft so the control can be stopped and held stationary for setting.

At the lower corner of *Fig.* 1, is shown an electrical rotary switch that works in conjunction with the turret-shaped drum projecting from the top of the gearbox. The body of this drum is plastic inlaid with vertical strips of brass, electrically connected to a common point. Contact fingers at the left side bear on the surface of the drum as it rotates at one revolution each 64 minutes. The camera-shutter circuit is wired through the fingers and the selector switch to choose the longer or shorter of the inlaid strips. Because of their spacing, these contact various of the fingers at intervals ranging from 2 to 64 minutes.

This arrangement supplies the rough control for camera exposure-interval—the individual exposures being determined to about 1 second accuracy through the action of the previously described exposure cam, which is fed through a geared system from the same synchronous motor as the rest of the speed-control unit. A second cam and limit switch control a small motor by the action of which a 2-inch by 10-inch camera plate is automatically advanced from position to position for five successive exposures.

TEMPERATURE CONTROL AND MEASUREMENT: When the pressure in the rotor chamber is less than 1 micron of mercury, frictional heating on the rotor is only sufficient to raise its temperature about 1 or 2 degrees Centigrade per hour at full speed. If, however, the surroundings are maintained at a temperature approximately 20 degrees below that of the rotor,

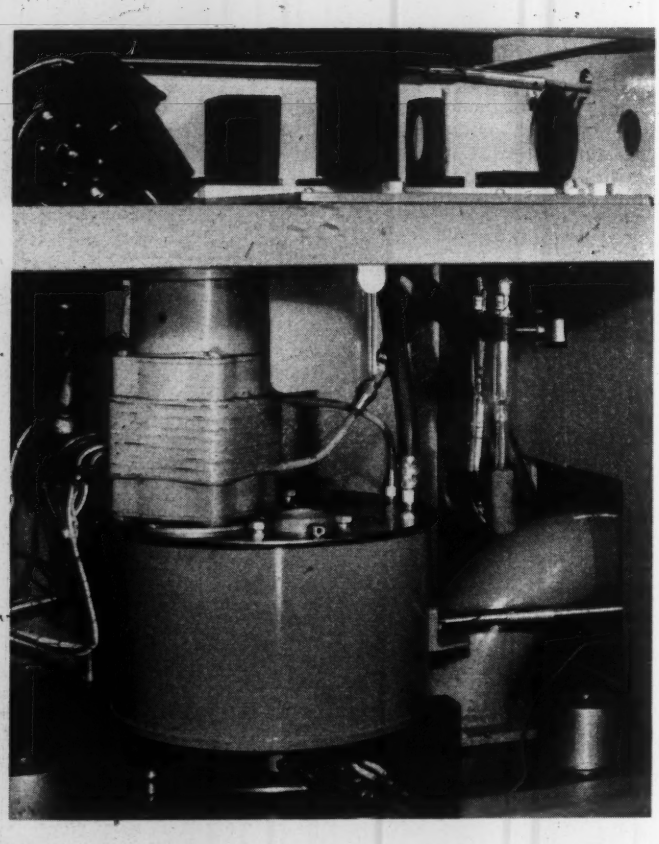


Fig. 7—Above—Drive in operating position. Rod at right carries reduced motion from drive to speed-control unit. Large curved pipe is vacuum line from oil-diffusion pump. Above drive are optics and blower for drive compartment

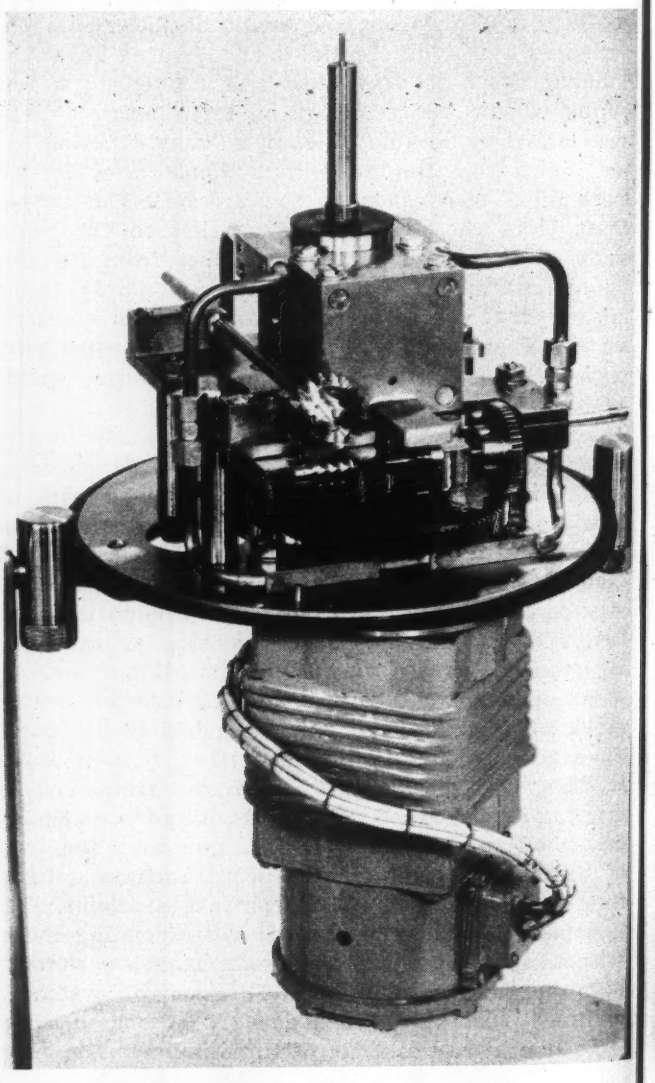


Fig. 8—Right—Partially disassembled drive, inverted. Large plastic spur gear is attached to motor shaft. High-speed output shaft projects at top. Other gear reductions are for control reference and tachometer drives

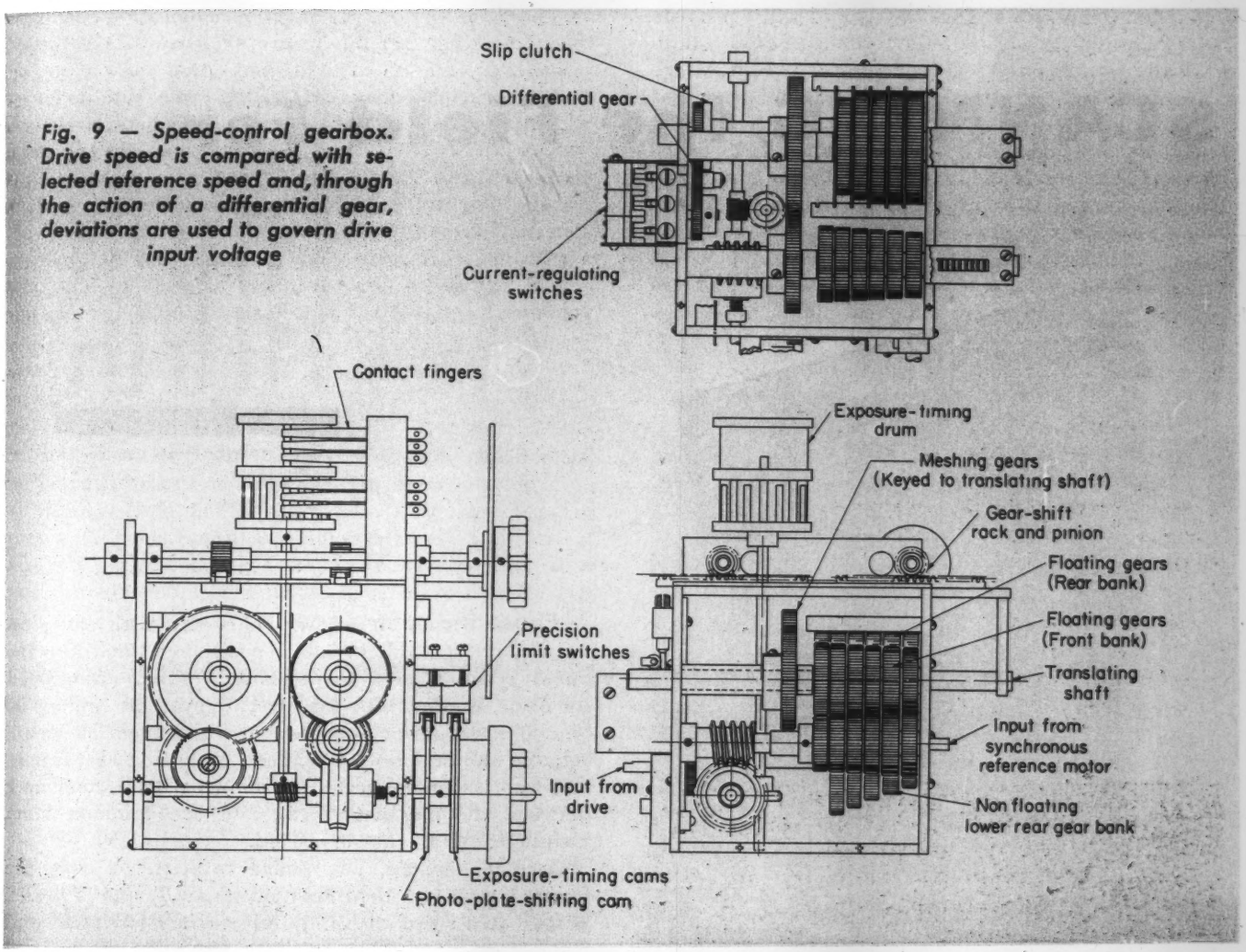


Fig. 9 — Speed-control gearbox. Drive speed is compared with selected reference speed and, through the action of a differential gear, deviations are used to govern drive input voltage

the rise can be reduced to zero and the rotor spun indefinitely without any significant change in temperature. Thus, the chilled copper liner which surrounds the rotor within the evacuated chamber makes it possible to maintain rotor temperatures even below freezing. Good thermal insulation between the liner and the main walls of the chamber are afforded by a narrow intervening gap which is of course evacuated. The compressor supplying refrigerant to the evaporator coils of the liner is of ¼-hp rating and a pressure control in conjunction with a capillary system is used to regulate the temperature.

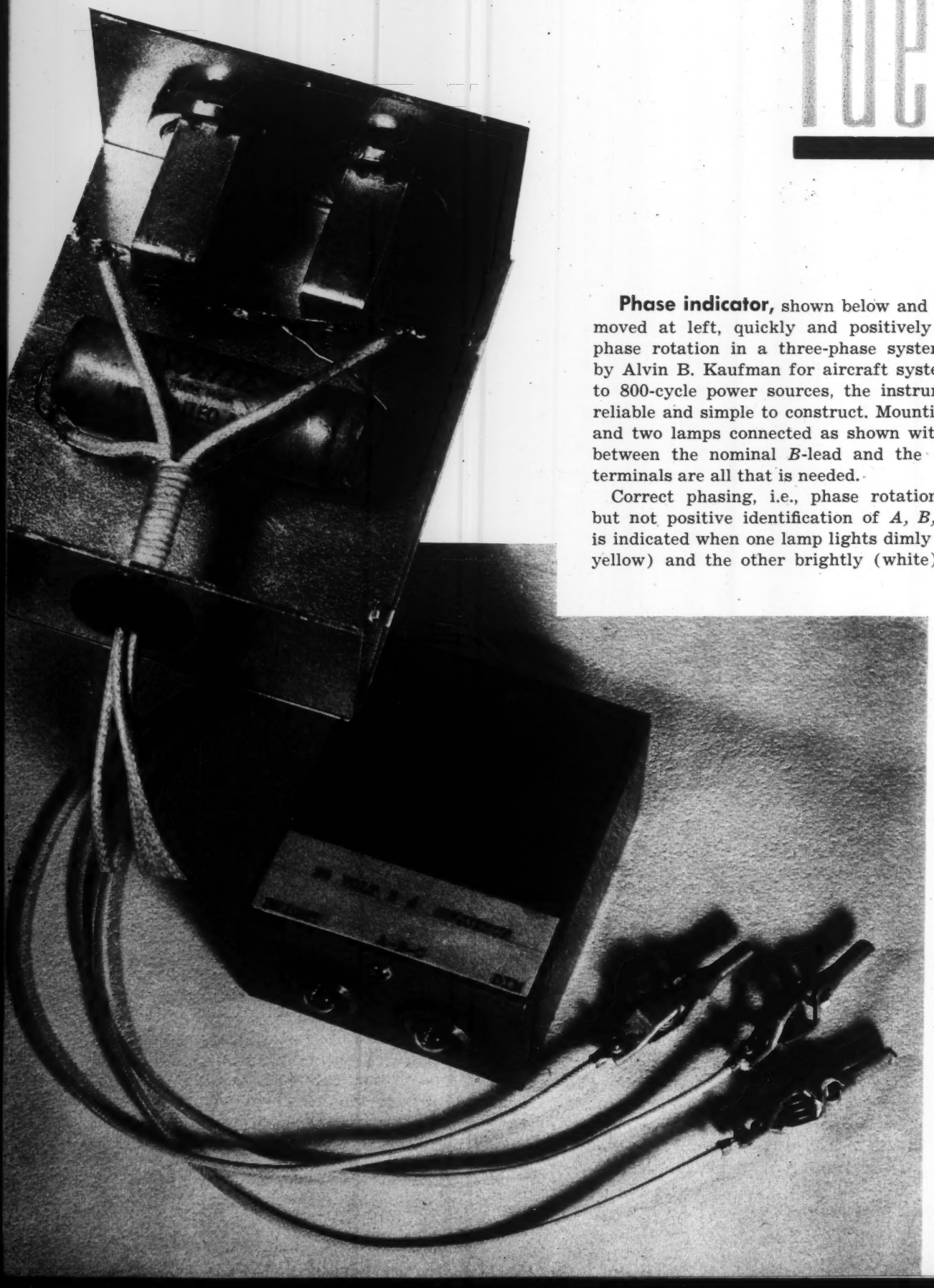
Temperature measurements of the rotor and other parts of the machine are made to within ±0.2 C by a system of thermocouples. The meter and switching controls are located in the upper right-hand panel of the machine, visible in *Fig.* 3. Couple elements are provided for measuring initial and final rotor temperatures by direct contact. A rough check on rotor temperature during operation is afforded by a radiation couple situated within the oil catcher above the coupling device.

VIBRATION AND NOISE: Because of the precision nature of the optical system and the dependence of final results on the accuracy of the sedimentation photographs taken, rather extreme measures were taken to isolate all traces of mechanical vibration. As will be apparent from *Figs.* 4 and 7, the light source, drive and main optical parts are housed in a box-like structure of ¼-inch steel. This is completely isolated from the rest of the frame by four neoprene pads at the base. The optical tube (not illustrated) is bolted and braced to this structure and extends across the top of the machine to the camera, located at upper right. The whole optical system is thus relatively free of vibration arising in the building, in the vacuum pump or in the refrigeration unit. These latter devices are suspended on soft springs for further isolation. Individual resilient mountings are used in other specific locations such as between the drive housing and its mounting base as shown in *Fig.* 6.

Noise has been minimized by the combination of a number of factors. The flexible-shaft and spindle-roller arrangement described as part of the drive imparts mechanical damping and resiliency to the high-speed members of the power transmission system. Operation of these parts within a sealed housing and continuous lubrication by an oil mist further reduce the generation of noise. Use of plastic-to-metal gearing is another contributing factor.

External to the mechanical system itself, fiberboard lining throughout the inner box-like structure and partial lining at critical areas in the outer enclosure further reduce what noise is emitted from the operating parts of the unit.

SCANNING the Field For Ideas



Phase indicator, shown below and with cover removed at left, quickly and positively identifies the phase rotation in a three-phase system. Developed by Alvin B. Kaufman for aircraft systems having 50 to 800-cycle power sources, the instrument is small, reliable and simple to construct. Mounting accessories and two lamps connected as shown with a condenser between the nominal *B*-lead and the common lamp terminals are all that is needed.

Correct phasing, i.e., phase rotation or sequence but not positive identification of *A, B,* and *C* leads, is indicated when one lamp lights dimly (filament dull yellow) and the other brightly (white). A reversal

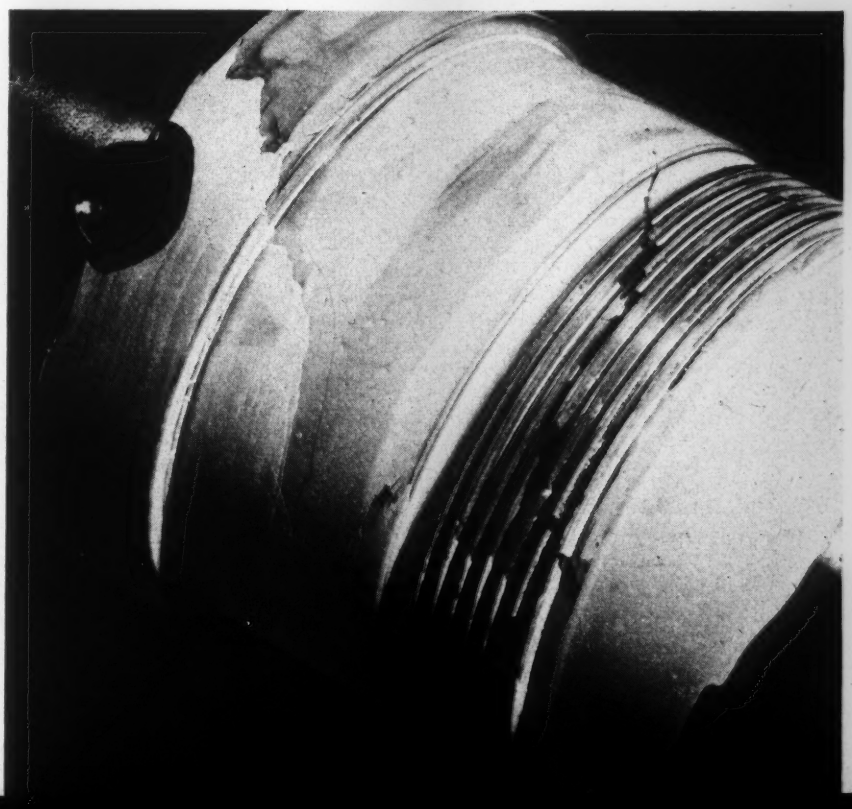
of phase rotation is indicated when the brilliance of these two lamps is reversed. Faulty indication may be noted when both lamps light to the same brilliance, or when only one lights. These conditions indicate a defective lamp in the unit, a disconnected test lead or no voltage on one phase.

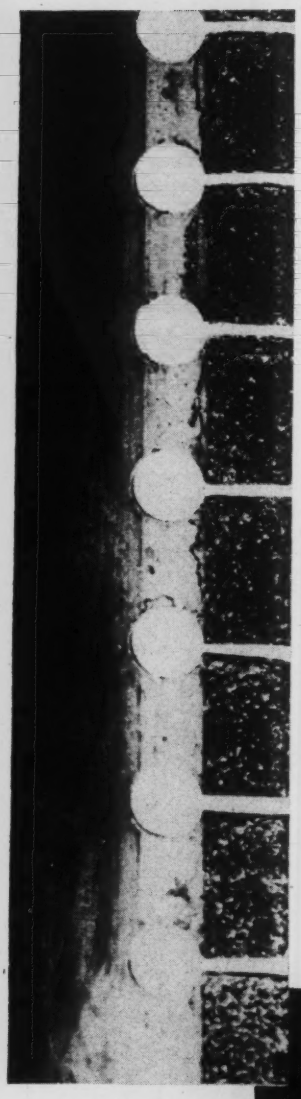
The lamps may be 110-volt 6-watt type for satisfactory operation on both 26 and 110-volt supply. Normally, for three-phase 26-volt 400-cycle aircraft systems 28-volt (Mazda 313) aircraft panel lamps would be used. The value of the condenser is not critical but should be selected for the line frequency utilized. Too high an impedance will cause both lamps to light dimly while too low an impedance will cause full brilliance of each. Capacitance values for this purpose are approximately 0.2 to 0.25 mfd for 110-volt circuits and 1.0 mfd for 26-volt 400-cycle circuits. The voltage rating of the condenser should be in proportion to the line voltage, the direct-current rating being approximately twice the alternating-current line voltage. The value of the condenser capacity is dependent upon the rating of the lamps and the line frequency so that the condenser can be selected for visible brilliance difference in the lamps.

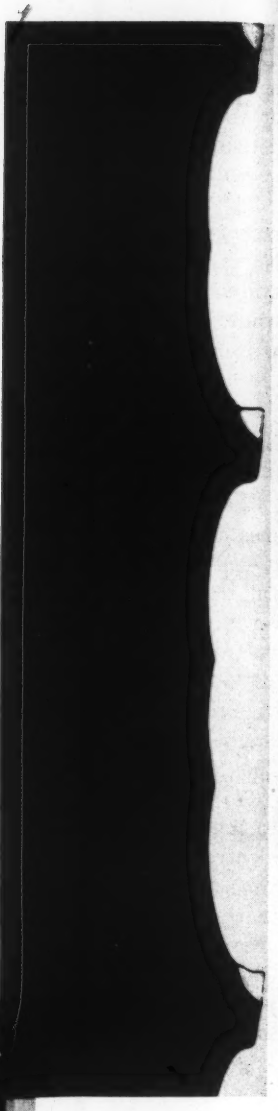
Sensitive vacuum gage, right, is capable of measuring pressures equivalent to one-thousandth of a billionth-inch of mercury. Looking like a radio tube and behaving in a similar manner, it is called an "ion gage" and can detect the presence of air in a vacuum where only one molecule remains out of every 10,000 billion originally present. This electronic device, developed by Robert T. Bayard at the Westinghouse Research Laboratories, is believed to be about 200 times more sensitive than any produced before.

To measure pressure in a vacuum, the gage is sealed to the system. Then the power is turned on, releasing electrons from a gun inside the gage, just as in a radio tube. When these electrons collide with air molecules in their path, they knock off part of the molecule to create a positively charged particle called an ion. The number of these ions formed in this way is an accurate measure of the pressure inside the system and can be indicated on an instrument. Previous ion gages were limited in their sensitivity because of false readings produced by X-rays inside the gage.

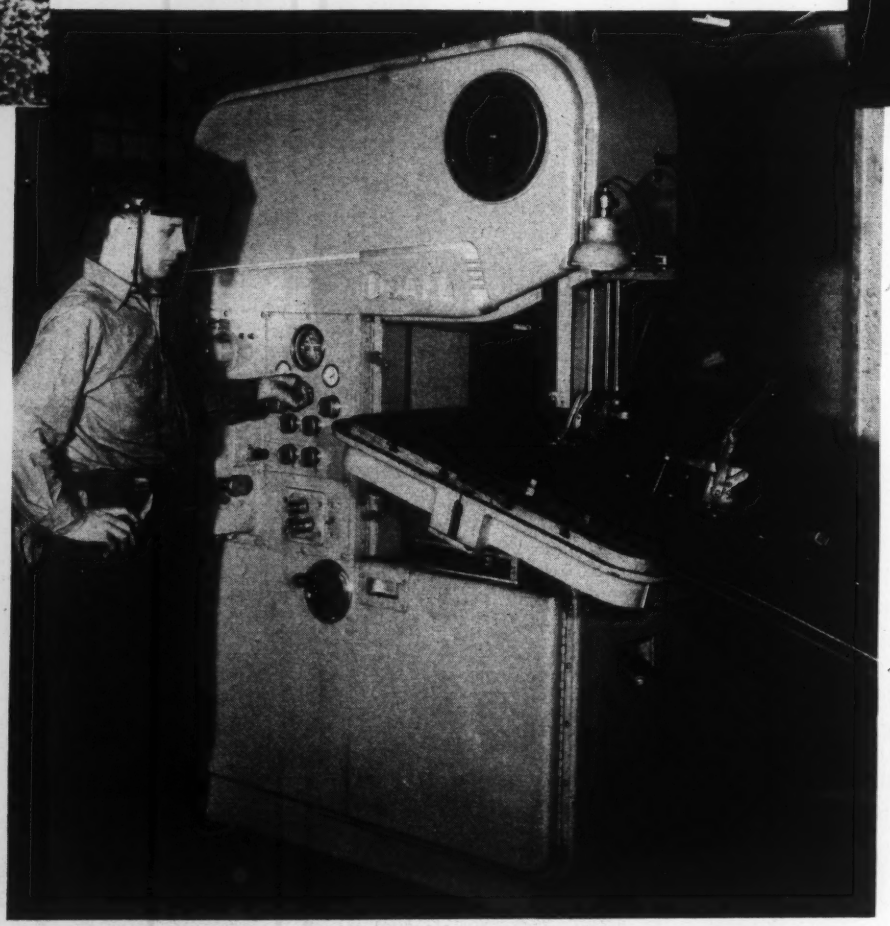
Cracks too small to be seen in ferrous and nonferrous metals may be detected quickly and simply with a new dye process developed at the Turbodyne Corp., a subsidiary of Northrop Aircraft. Employing the principle of the ability of a red dye to bleed through an overcoat of white, the method clearly indicates the size and probable depth of cracks as indicated on the crankshaft shown at right. In use the dye is applied to the surface of a suspected part and allowed to stand for five minutes. The dye is then wiped off and a white developer solution is applied. Any cracks existing in the part are detected by the presence of fine red lines or dots as the dye, which possesses high capillary action, is drawn from the fissure by the developer.







Line milling, performed on the band machine below, employs a band with tungsten-carbide tipped teeth, doubling cutting rates and tool life. The band tool, left, withstands high frictional temperatures encountered at the tooth tip and is useful for cutting materials of low thermal conductivity, as well as certain air-hardening and abrasive type materials. Line grinding, also performed on this same machine, is employed for cutting and shaping hardened dies, tools and high-temperature alloys. Cubical molded abrasive matrices are welded in the form of teeth, right, on the band. The machine, developed by the DoAll Co., employs hydraulic operation for tool speed, work table feed, tool post, table tilt, blade tension, and brakes, operation being controlled from a central panel. Stepless speed range from 40 to 10,000 fpm is available for cutting speeds.



". . . conduct independent research . . . to keep their organization informed of new technical arts . . ."

By Randolph W. Chaffee
Consulting Engineer
Cleveland, Ohio

Engineering Management —Its Job

Photo, courtesy Consolidated Vultee Aircraft Corp.

The whys and wherefores of engineering management, how it is organized and carried out from the inception of an idea to the finished machine or product

Part 4—Direction of Engineering

SCHEDULING of a creative engineering project is the timing of the project and the forecasting of the number of man-hours and dollars to be expended in completing the project. It is not practical to schedule a whole project stage as one entity; the work of each stage must be broken down into the work components performed by the different types and classes of creative engineering personnel involved.

ENGINEERING PERSONNEL: Classification of engineering personnel must recognize two fundamental distinctions. One of these distinctions lies between the personnel of creative instincts and the personnel of executionary instincts. The creative personality is inventive, capable of original thinking, ingenious, and largely self-motivated. Generally, it is also temperamental, emotional and not greatly interested in the smaller details. The opposite personality is adapted to carry out precisely and faithfully the ideas of others, to endow those ideas with weight and substance and to translate them into practical operation.

The second vital distinction reflects the different technical arts which make up creative engineering such as mechanical, structural, chemical, electrical, aesthetic, etc. Failure to observe the boundary lines between them can produce tragic results. Engineering personnel are also classified according to degree of skill within each technical art but this concept is common and needs no explanation here.

For purposes of planning and scheduling engineering projects, engineering personnel classifications are recognized as outlined in the following paragraphs.

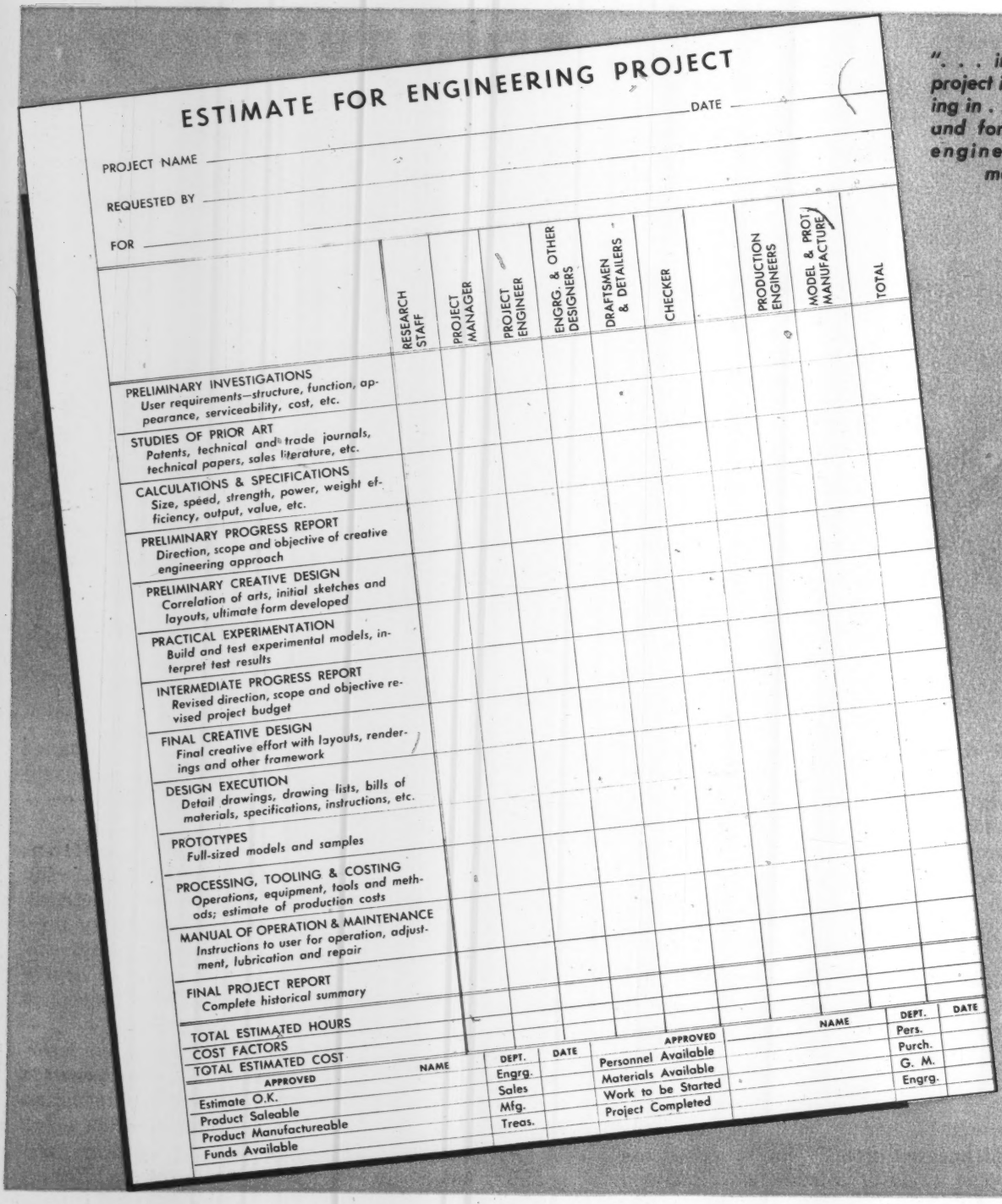
Research Staff: The research staff is made up of the technical specialists such as civil engineers, mechanical engineers, electrical engineers and others

who possess superior education, training and experience in their respective fields. These engineers contribute to all company projects which involve their specialties. In addition, they conduct such independent research as may be needed to keep their organization informed of new technical arts and also they may be involved in other duties as defined by outside sponsor enterprises. This staff should be "freelance" in function and should be composed generally of the older and more experienced creative engineering personnel.

Research functions primarily in *Stages A, B* and *C*, dicussed in the previous article, and collaborates to whatever extent it may find necessary to insure that succeeding stages follow the correct pattern.

Project Manager: Apart from both the research function and the application of technology to the individual project, there is a need for project liaison, project integration with the sponsoring enterprise and supervision of the commercial aspects of the creative engineering project. As indicated in the previous article, this individual is generally known as the project manager and takes full responsibility for the planning, scheduling, budgeting, direction, and reporting of the project. A project manager may supervise at one time one or more projects depending upon their total scope and remains identified with each of the projects from its inception to its completion.

Insofar as it is possible to find in one personality



ESTIMATE FOR ENGINEERING PROJECT

PROJECT NAME _____ DATE _____

REQUESTED BY _____

FOR _____

	RESEARCH STAFF	PROJECT MANAGER	PROJECT ENGINEER	ENGRG. & OTHER DESIGNERS	DRAFTSMEN & DETAILERS	CHECKER		PRODUCTION ENGINEERS	MODEL & PROT. MANUFACTURE	TOTAL
PRELIMINARY INVESTIGATIONS — User requirements—structure, function, appearance, serviceability, cost, etc.										
STUDIES OF PRIOR ART — Patents, technical and trade journals, technical papers, sales literature, etc.										
CALCULATIONS & SPECIFICATIONS — Size, speed, strength, power, weight efficiency, output, value, etc.										
PRELIMINARY PROGRESS REPORT — Direction, scope and objective of creative engineering approach										
PRELIMINARY CREATIVE DESIGN — Correlation of arts, initial sketches and layouts, ultimate form developed										
PRACTICAL EXPERIMENTATION — Build and test experimental models, interpret test results										
INTERMEDIATE PROGRESS REPORT — Revised direction, scope and objective revised project budget										
FINAL CREATIVE DESIGN — Final creative effort with layouts, renderings and other framework										
DESIGN EXECUTION — Detail drawings, drawing lists, bills of materials, specifications, instructions, etc.										
PROTOTYPES — Full-sized models and samples										
PROCESSING, TOOLING & COSTING — Operations, equipment, tools and methods; estimate of production costs										
MANUAL OF OPERATION & MAINTENANCE — Instructions to user for operation, adjustment, lubrication and repair										
FINAL PROJECT REPORT — Complete historical summary										
TOTAL ESTIMATED HOURS										
COST FACTORS										
TOTAL ESTIMATED COST										

APPROVED	NAME	DEPT.	DATE
Estimate O.K.		Engrg.	
Product Saleable		Sales	
Product Manufactureable		Mfg.	
Funds Available		Treas.	

APPROVED	NAME	DEPT.	DATE
Personnel Available		Pers.	
Materials Available		Purch.	
Work to be Started		G. M.	
Project Completed		Engrg.	

". . . initiator sets the project in motion by filling in . . . estimate form and forwarding to the engineering department . . ."

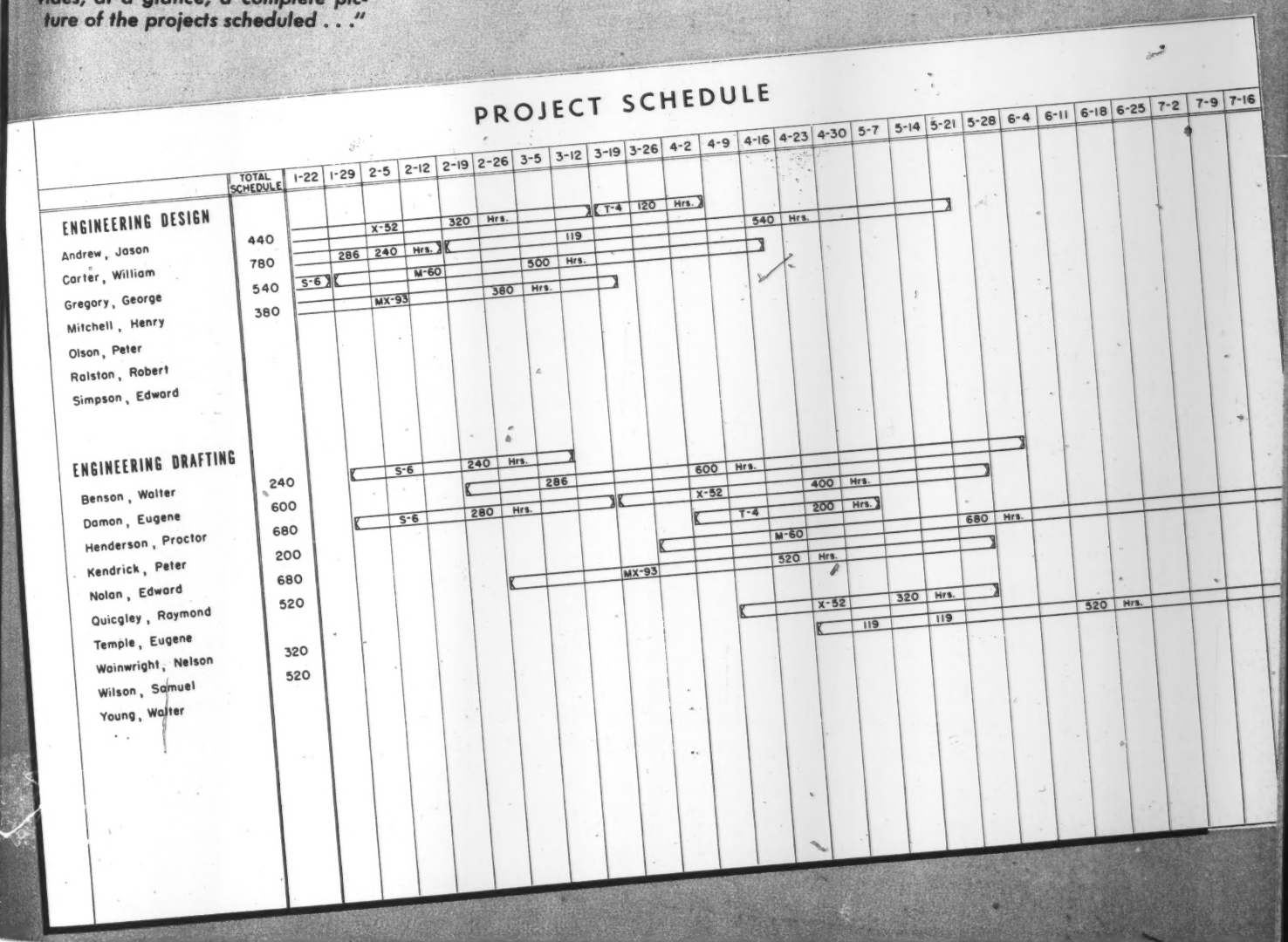
instincts both creative and executionary, this combination should be present in the project manager. While not necessarily an outstanding creative engineer, this individual must have enough creative instinct to appraise technical art intelligently as applied to his projects and to stimulate the creative instincts of his subordinates. A very considerable capacity for administrative detail is needed for accurate liaison and interpretation, supervision of records and reports, co-ordination of multiple project components, and all the nontechnical details of creative engineering projects. The project manager plays a leading part in *Stages A* through *D*, with a diminishing role in the subsequent stages as the roles of his subordinates increase in importance.

Project Engineer: Supreme creative personality in the central engineering group hereinbefore described is the project engineer who supplies the greatest original contribution to project technology. In addition to his special qualifications in the predominant technical art of the project, he adapts other technical arts to the program with the assistance of the research staff. The project engineer supervises directly the work of the whole central engineering group except insofar as the routine may be affected by other related jobs.

The project engineer takes the lead in all stages of the engineering project. Except in respect to very minor projects, the project engineer concentrates upon only *one* project at *one* time in order that each project may advance as rapidly as possible.

Pool Personnel: Greatest flexibility and utility of engineering personnel is achieved when all but those in the foregoing positions are considered to make up a personnel pool of engineering assistants, designers, technicians, draftsmen, detailers, checkers, analysts, and others. Individuals are drawn from this pool to make up the project staff, according to the project requirements and their individual capabilities. They remain members of the project staff for its duration and are returned to the pool when the project is completed. The composition of the project staff is not fixed but may change from time to time as project requirements advance and change. Pool personnel

". . . well-known bar chart . . . provides, at a glance, a complete picture of the projects scheduled . . ."



are charged to the project only during such time as they are needed and productively employed.

Also included in this pool are the junior technicians engaged in special laboratory work and minor research for individual projects, the shop model builders and testers and all other members of the engineering organization.

TIMING OF ENGINEERING PROJECTS: No element of engineering management is more difficult than the forecasting of the length of time which will be required to complete a creative engineering project. There is no magic formula into which are inserted known values to compute the probable duration of creative undertakings. Like swimming and piano plying, the art is mastered only by practice over a period of time and success comes only from the intelligent and persistent application of determined effort.

At the outset of an engineering management program, with no record of previous experience, engineering projects cannot be scheduled realistically. The engineering staff is not conditioned to think of time and is incapable of forecasting time. Ergo, the first step is the establishment of a record system which shows, by stage and class of engineering talent, the number of hours expended. The record form and data are described in some detail later in this discussion.

After about six months of record keeping, plus a growing consciousness of time among the engineers, it should become possible to relate time to engineering projects. Not more than two years of this effort should be needed to achieve a useful record along with a capability for realistic and fairly accurate forecasting of creative engineering projects.

The greatest difficulty is found, as might be expected, in forecasting the purely creative work outlined in *Stages A* through *G* of the previous articles.

". . . schedule is put into effect by work assignments to individual members . . . to convey full information . . . special instructions . . . dates . . ."

ASSIGNMENT

ASSIGNMENT INSTRUCTIONS	STAFF NO.	PROJECT NO.
	NAME	
	DEPT.	
	APPROVED	
PROJECT NAME	DATE TO START	
OPERATION	DATE TO FINISH	

JOB RECORD

CLOCK TIME	HOURS		RATE	AMOUNT	STAFF NO.	PROJECT NO.
		IN				
		OUT			NAME	
		IN				
		OUT			DEPT.	
		IN				
		OUT			APPROVED	
TOTALS					COMPUTED	
PROJECT NAME					POSTED	
OPERATION						

". . . form shows hours expended by each member of the engineering staff . . . by project and operation for summary of project costs . . ."

Consequently, these demand the greater degree of "skull-practice" in forecasting. Even in these stages however, one experiences a growing flair for anticipation and a growing appreciation for the scope and depth of creative engineering to be encountered.

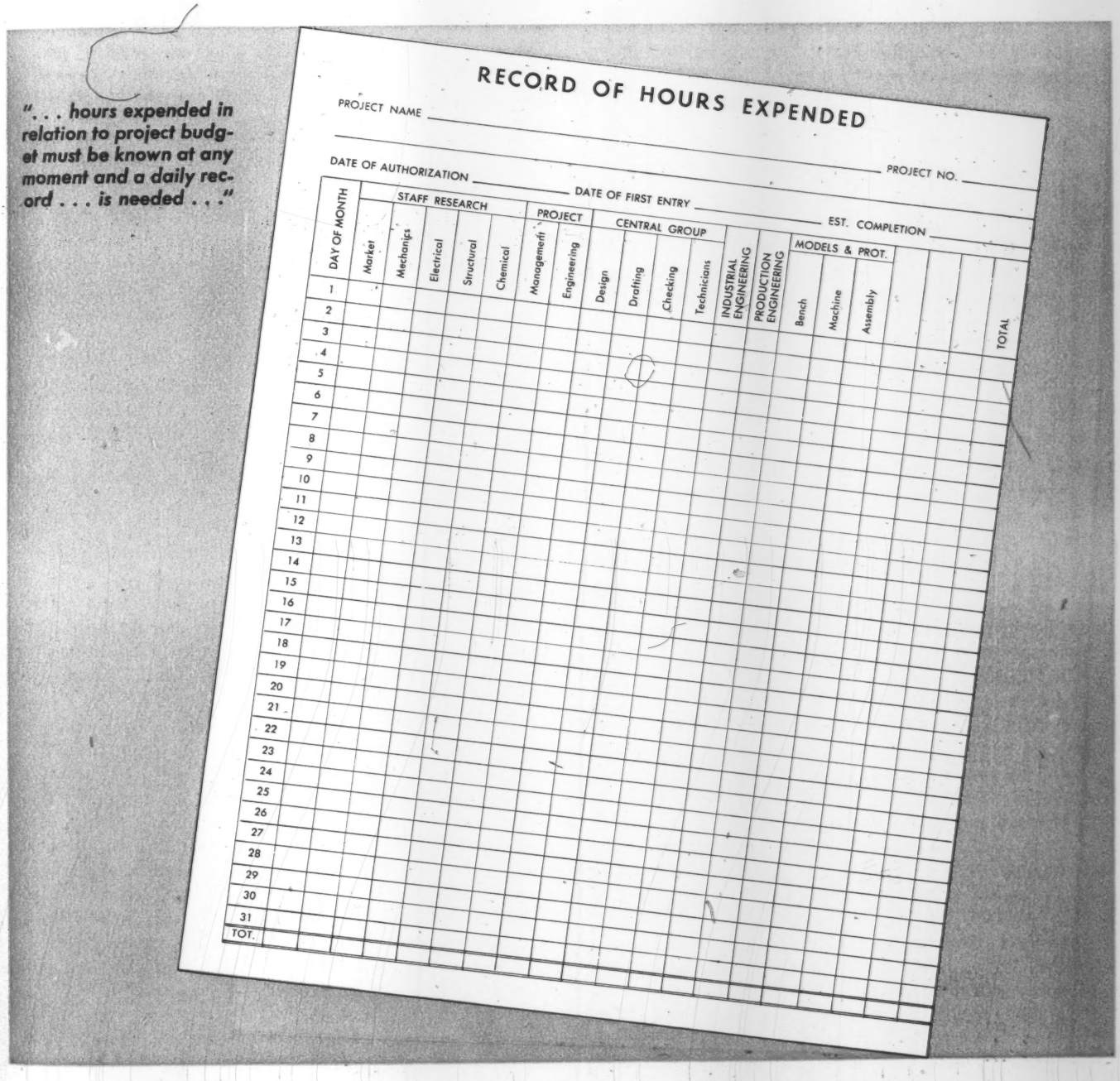
Executionary *Stages H* through *M* are more routine. It is discovered, for example, that the making of a detailed drawing of a single component will generally consume from 10 to 15 hours, that a subassembly drawing can be estimated at an average of 35 hours. and that checking will require 25 per cent of the total of detail drafting time. Other standards will emerge as the record and estimating experience expand.

Estimating for an engineering project normally occurs as a prelude to obtaining authorization to conduct the project and the estimate forms a part of the request to higher management for such authorization.

ESTIMATES FOR ENGINEERING PROJECTS: The estimate form may be initiated in any one of several places. The sales department may initiate it as a request, when a product redesign or a new product design is wanted by that department. The manufacturing department may initiate it for changes in production equipment or the research staff may initiate it where practical experimentation is desired by that staff. The initiator sets the project in motion by filling in the heading of the form, Estimate For Engineering Project, and by forwarding it to the engineering department.

After suitable investigation, the engineering department fills in the body of the request form showing the number of engineering hours estimated to be required in each of the steps involved. These hours are extended by Cost Factors to advise the accounting department of the approximate financial obligation and to permit that department to fit the project into the overall budget The engineering de-

". . . hours expended in relation to project budget must be known at any moment and a daily record . . . is needed . . ."



RECORD OF HOURS EXPENDED

PROJECT NAME _____ PROJECT NO. _____

DATE OF AUTHORIZATION _____ DATE OF FIRST ENTRY _____ EST. COMPLETION _____

DAY OF MONTH	STAFF RESEARCH					PROJECT		CENTRAL GROUP				INDUSTRIAL ENGINEERING	PRODUCTION ENGINEERING	MODELS & PROT.						TOTAL
	Market	Mechanics	Electrical	Structural	Chemical	Management	Engineering	Design	Drafting	Checking	Technicians			Bench	Machine	Assembly				
1																				
2																				
3																				
4																				
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partment may find the project unsuitable, as originally requested, and may cause the project to be modified or voided.

If the engineering department finds the project to be suitable, the estimate form is passed successively through the sales department for approval of the saleability of the end product, the manufacturing department for certification that the product is manufactureable, the treasurer or comptroller for certification that funds are available, the personnel department and the purchasing department where questions of personnel and materials availability are involved, and finally to the general manager or other senior executive who authorizes that the engineering project be started.

SCHEDULING THE INDIVIDUAL PROJECT: Only the engineering department should decide the date when the individual engineering project can be started, the persons who will be engaged on it, how long it will continue, and when it will finish. These decisions can be made intelligently only in relation to the projects previously in process, the personnel available and their individual skills, and the correlation of the several stages in the project. For the purpose of setting up the new project, no better device can be found than the well-known bar chart which provides, at a glance, a complete picture of the projects scheduled.

The personnel of the engineering department comprise its capacity and this working capacity is grouped on the Project Schedule chart by classifications such as Research Staff, Project Management, Project Engineers, Engineering Design, Engineering Drafting, etc. The name of each individual appears as

WEEKLY STATUS REPORT

PROJECT NAME _____ PROJECT NO. _____

_____ WEEK ENDED _____

_____ DATE OF AUTHORIZATION _____

PROJECT MGR. _____ DATE OF FIRST ENTRY _____

PROJECT ENGR. _____ ESTIMATED COMPLETION _____

		BUDGET—HOURS			EXPENDITURES—HOURS			BUDGET BALANCE HRS.	SCHED. COMP. DATE	CURRENT STATUS	
		Original	Revisions	Current	To End Last Week	Current Week	Total To Date			Per Cent Expend.	Per Cent Comp.
STAFF RESEARCH	MARKET										
	MECHANICS										
	ELECTRICAL										
	STRUCTURAL										
	CHEMICAL										
PROJECT	MANAGEMENT										
	ENGINEERING										
CENTRAL GROUP	DESIGN										
	DRAFTING										
	CHECKING										
	TECHNICIANS										
INDUSTRIAL ENGRG.											
PRODUCTION ENGRG.											
MODELS & PROTOTYPES	BENCH										
	MACHINE										
	ASSEMBLY										
TOTAL											

". . . key instrument of engineering administration . . . provides the engineer with information . . . to direct efforts toward completion of the project . . . within its budget . . ."

a unit of capacity in each group. As each assignment is made, the bars are extended to the right, across the columns which indicate weeks, from the beginning of each assignment to the scheduled end. Each bar is marked to show the assignment number, or identification, and the number of scheduled hours. When brought up to date, the chart shows the total relationship of work load to capacity, the personnel available earliest for additional assignments, the types of work needed to preserve a balanced work load or the classifications of personnel needed to handle the work load, the rate of progress and scheduled completion date of each project in each stage, etc.

The chart form illustrated is but the nucleus of this record and it may be altered or expanded to serve the needs of any enterprise where it may be used. Where a useful purpose is served, this same form of chart may also be made up for the individual project only.

Chart Basis for Scheduling

This method of scheduling projects has many uses. As the new project is fitted into the overall work load, the chart gives a realistic indication of the date when the project will be completed, and provides a basis for advising the sponsor of this date. It can be used to forewarn other interested departments, such as the model shop, as to when their services will be needed. The schedule shows when materials will be needed for fabrication of models and prototypes, for the information of the purchasing agent, and it helps to forewarn the personnel department of impending need for additional engineering personnel.

All too often, a co-ordinated schedule is upset to allow insertion of a new job which the sales department wants to sell on the basis of early delivery, and the upset is made without actual knowledge of the effects. The sales department may say, "slip this into your schedule so that we can close this order—it won't take long or do any harm." With a carefully worked-out schedule, the engineering department can show to the sales department just how long the new job will take, what current project will be delayed and which sponsors will be disappointed by delays in their projects. In fact, the engineering department is armed with realistic data to say to the sales department, "These are the current sponsors whose projects are in work and whose projects will be delayed if we insert this new project. This is the amount of delay to each of the current projects. Will you take the responsibility of advising these sponsors regarding these delays and of keeping them happy despite them?"

The scheduling method does not prevent alterations in the schedule but it does point out the practical effects of alterations and enables a realistic appraisal of the effects of changes. When these effects are known, the importance of a new project which upsets the schedule can be viewed in proper perspective and the number of schedule upsets may be considerably reduced.

While there are many methods of setting up the relationship of work load to capacity, including tabular and other forms, no method seems to be as clear or as quickly understood as the graphic bar chart. Neither does any seem as versatile in meeting the many and varied needs of intelligent management of creative engineering.

Assignments: The schedule is put into effect by work assignments to individual members of the engineering staff and an Assignment form is employed. For ease in filing by staff member and/or project, the form is a card 4 by 6 inches. The original is given to the staff member to convey full information on the assignment including special instructions and the dates when this assignment is scheduled to be started and finished. The original copy remains in the staff member's possession for the duration of the assignment while other copies are on file with the engineering administrator.

At the outset of a new scheduling procedure, assignment cards may be made up only shortly before the Date To Start to allow for last-minute changes in the schedule. After the procedure has been ironed out and is operating more smoothly, cards may be made up and given to staff members well in advance in order that preparatory work on new assignments can be carried out.

With the preparation of assignment cards, scheduling stage of engineering is completed and the engineering management process becomes one of administering, recording and reporting.

ADMINISTRATION, RECORDS AND REPORTING: The purpose of engineering management is not one of control in the more literal or disciplinary sense. Rather, its purpose is to enable engineering personnel to police their own conduct and to provide the information for realistic estimating of engineering projects. To be more specific, a major purpose of the procedure herein described is to keep the engineering staff informed of the hours expended in relation to the budget hours in such terms that each member of the engineering staff may make his effort to stay within the budget or to present good reason for overrunning it.

Cards to Summarize Costs

Daily Job Reports: The Job Record form is a listing of original entry which shows the hours expended by each member of the engineering staff by project and operation. This is a partial duplicate of the assignment card, 4 by 6 inches, and is prepared each day or part thereof that time is to be charged to the project. With only a single project and operation on each card, the cards may be collated by project and operation for summary of project costs. Where desired, the job record card may also support the payroll of the engineering department.

The form employed is adapted for punching in an electric clock during morning, afternoon and overtime In and Out spaces at the left margin of the card, and this is a convenient method of recording time without human error. As a result of its similarity to the assignment card in the engineer's position, the job record card may be copied directly from the former, each time it is made out. The job record cards are collected at the end of each day for posting to the

Record of Hours Expended report.

Record of Hours Expended: There are many crucial situations where the hours expended in relation to the project budget must be known at any moment and a daily record of hours expended is needed. Column headings of the sample form, Record of Hours Expended, indicate the categories in which hours expended are grouped, both in the initial estimate and in the record which supplies the data for comparison with that estimate. These headings should be adjusted to fit the needs of the engineering organization in which this administrative procedure is used.

The hours entered on the job record for each project and day are posted directly to the record of hours expended daily according to the engineering categories which appear under Operation on the job record, and in the column headings of the record of hours expended. Blank columns are provided at the right side of the record of hours expended for special operations as they may occur.

A subtotal is taken weekly on the record of hours expended and the line for the weekly subtotal is the day of the month of the Sunday following that week. The weekly subtotal is transferred to the Weekly Status Report.

Key to Direction of Efforts

Weekly Status Report: All that has been described hereinbefore leads up to and supports the key instrument of engineering administration — the Weekly Status Report. This report provides the engineer with the information he needs to direct his efforts toward completion of the project as nearly within its budget as possible. It provides forewarning of budgetary overrun and the need to shift engineering personnel to stay within the total budget or to arrange for alterations in the budget. It provides, in short, the intelligence needed to give the sponsor in the engineering project full value as originally defined—no more and no less.

The original budget hours for each stage and work classification are shown under the heading, Budget-Hours, to remind the engineers of the value originally attached to those parts of the project, the revisions subsequently made to the original budget and the current authorized budget.

Actual expenditures against the budget appear in the columns, Expenditures-Hours. Total-To Date hours of the previous week's report appear under To End-Last Week on the current week's report. To this is added the hours expended during the Current Week to make the current Total-To Date. Budget Hours-Current minus Expenditures-Hours, Total-To Date, equals Budget Balance-Hours and shows how much of the currently authorized budget remains available. Scheduled Completion Date reminds the engineers of the date when each stage and work classification should be completed.

The current status of the engineering project is indicated in two ratios. The ratio Percent Expended is the quotient of Expenditures-Total to Date to Budget-Current, and shows what portion of the authorized budget has been expended. The ratio Percent Completed is determined each week as realistically as possible by the project engineer to reflect the degree of completion from the technical and creative point-of-view, apart and independently of the previous ratio.

Comparison of these ratios indicates the project status. When the Percent Expended ratio exceeds the Percent Completed ratio, the project is falling behind the budget and action is needed to bring the project into line. When the ratio Percent Completed exceeds the ratio Percent Expended, in a stage of work, that stage has gotten ahead of the budget and manpower can be diverted therefrom in order to help along any work stage which has fallen behind schedule.

An excellent administrative device in creative engineering is the weekly project conference among all staff members assigned to the project. The weekly status report is reviewed during this conference so that all staff members are informed of the project status and all members contribute ideas and suggestions for the better conduct of the project during the coming week.

Following the weekly project staff conference. copies of the weekly staff report may be transmitted to the project sponsor with explanations for delays and forecasts of action to be taken to keep the project within the current budget.

To summarize, the weekly status report has three important purposes. First, it enables the engineering staff to keep advised of the project status and the action needed to keep the engineering in line with the original budget. Second, it maintains co-ordination with other departments that depend upon engineering. Third, it conveys to sponsors concrete evidence of the integrity of the creative engineering function in respect to keeping within the budget and of returning full value for the funds assigned for creative engineering.

CONCLUSIONS: As stated previously in this series, careful, accurate and complete preplanning of engineering operations is the keystone of modern efficient industrial enterprise. To open the way to even greater technological achievements, to increased services at low costs, and to continuing improvement in the standard of living, highly developed administration of engineering must be more widely promoted and recognized. With efficient, enlightened administration bringing to fruit the latent talent of technology and creative engineering, horizons unlimited will be revealed.

Most Powerful Motors Built

TWO 65,000-hp synchronous motors, believed to be as powerful as any ever built, have been shipped by General Electric to the Bureau of Reclamation for use in the Columbia Basin Irrigation Project in Washington. The motors will drive the world's largest pumps, each capable of pumping more than a billion gallons of water a day. The motors each weigh more than 330 tons, are 25 ft high and 100 ft around the base.

Automatic Dynamic Balancers

Part 1—The Leblanc Balancer

By Ernest L. Thearle
Mechanical Engineer
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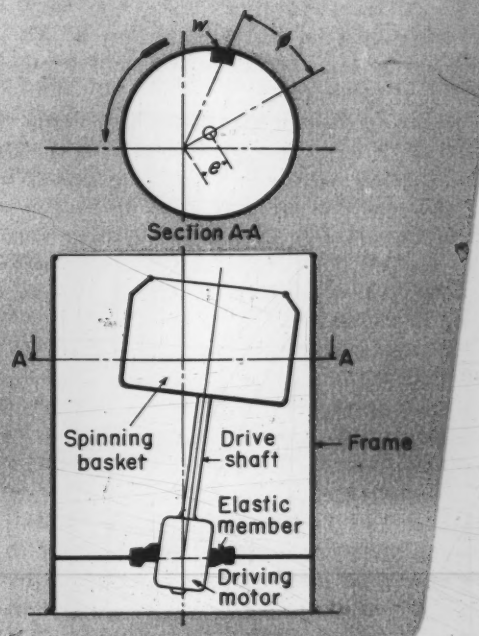


Fig. 1—Diagram of typical centrifugal extractor

DURING the last few years considerable interest has developed in the automatic balancing of rotating bodies. This interest has centered mainly around the application of such devices to the centrifugal extractors of domestic laundry machines. A real need exists here, as evidenced by the fact that a number of manufacturers of such machines have recently incorporated automatic balancing devices in their designs.

It is obviously preferable not to have to bolt a domestic laundry machine to a heavy foundation for the purpose of isolating any vibration that may exist. Also, it is impractical to expect the operator of such a machine, even if present at the start of the spinning cycle, to be an expert balancer capable of distributing the load properly to obtain a suitable balance.

The commonest attempt to solve, or circumvent, this problem has been to design the machine with a low critical speed, a relatively low spinning speed and an execessive amount of damping. This approach assumes that the washing action of the machine will distribute the load sufficiently uniformly so that the machine will pass through the critical speed without excessive vibration. This is not a satisfactory solution.

Low spinning speed results in unsatisfactory extraction performance. To obtain good extraction, the spinning speed should be in the neighborhood of at least 1100 rpm, or possibly 1700 rpm. Because extracting action varies about as the square of speed, a relatively slight increase in spinning speed should result in considerable improvement in extraction. Low critical speed simply lessens the observed effects of unbalance. Spinning action of many machines is frequently demonstrated with a load consisting of a large number of small pieces, such as handkerchiefs, which distribute themselves during washing more uniformly than would a few large pieces. This is obviously an unfair demonstration.

SELF-BALANCING centrifuges, applied today in large numbers to automatic home-laundry machines, have been developed in a variety of forms. In a series of three articles, of which this is the first, these systems—old and new—will be discussed and their characteristics compared to the specifications for the ideal balancer. Mr. Thearle, formerly head of Mechanical Investigations Division of GE's Research Laboratory and a well known authority on balancing, comprehensively treats a complex subject of growing interest

In this article, analyses will be given of some of the different kinds of automatic balancers now available for application to domestic laundry and other machines.

GENERAL PRINCIPLES: An understanding of the rotating system and recognition of its desired characteristics are essential to the subsequent analyses of different types of balancers.

Rotating System: In *Fig.* 1 is shown a vertical cross-section through a typical centrifugal extractor. Here the driving motor is shown mounted on the frame of the machine by means of an elastic member. The latter member is shown as a rubber ring surrounding the motor. The driveshaft extends upward from the motor and carries the spinning basket in which the load is placed.

A horizontal cross-section through the basket at the plane *A-A* is also shown in *Fig.* 1. The unbalance is represented by the weight, w. This view shows the basket displaced radially, as it would be at some instant during rotation due to the effect of the unbalance.

It should be noticed that the radial displacement or eccentricity, e, of the basket is not in the direction of the unbalance, but falls behind it by the angle of lag, ϕ. Both these quantities vary with the speed of the rotor.

It may be shown, either experimentally or analytically, that eccentricity, e, and angle of lag, ϕ, vary with the rotative speed as shown by the curves of *Figs.* 2 and 3, respectively. The shapes of these curves depend upon the amount of damping in the system. This damping is indicated on the curves by the quantity, b, the numbers being purely relative. Angular acceleration of the rotor has an effect on these quantities similar to that of damping.

In *Fig.* 2 it is shown that radial displacement or eccentricity, e, increases with rotative speed, reaches a maximum at the critical speed, N_c, and then decreases above this speed. Thus the machine is most sensitive to unbalance at the critical speed. At any one speed, eccentricity, e, is proportional to the amount of unbalance.

In *Fig.* 3 it is shown that angle of lag, ϕ, is small at low speeds and increases with speed. It passes through a value of 90 degrees at the critical speed and approaches 180 degrees at higher speeds. Rapidity of increase of the angle of lag depends upon the amount of damping, the change being very abrupt at the critical speed when the amount of damping is small.

At speeds below the critical, the rotor may be said to rotate with the "heavy side out," and at speeds above the critical, with the "light side out." Thus, to be effective over the whole speed range, an automatic balancer must react differently at speeds below the critical than it does at speeds above the critical.

The curves of *Figs.* 2 and 3 illustrate the fundamental performance of a rotating system such as that shown in *Fig.* 1. The design of any successful automatic balancer must be based on these inherent relationships.

Requirements of Ideal Balancer

Desired Characteristics of Automatic Balancer: In order to meet the requirements of a domestic laundry machine or any similar centrifuge, an automatic balancer should have the following four characteristics:

1. The balancer should be completely effective, correcting for all of the unbalance and not only a part of it
2. In order that the machine shall pass through the critical speed smoothly, the balancer should be effective at speeds below the critical. The device should continually act to balance the rotor as it approaches the critical speed, since this is the speed at which the system is most sensitive to unbalance
3. In order to compensate for changes in the unbalance at high speed due to extraction, etc., the balancer should act to balance the rotor at speeds above the critical. Because the angle of lag, ϕ, varies almost 180 degrees over the whole speed range, the balancer must be sensitive to speed and thus act differently at high speeds than it does at low speeds
4. The correction introduced by the balancer should

Fig. 2—Graph of eccentricity of extractor basket versus speed. Damping and angular acceleration, represented by different values of (b), also affect eccentricity

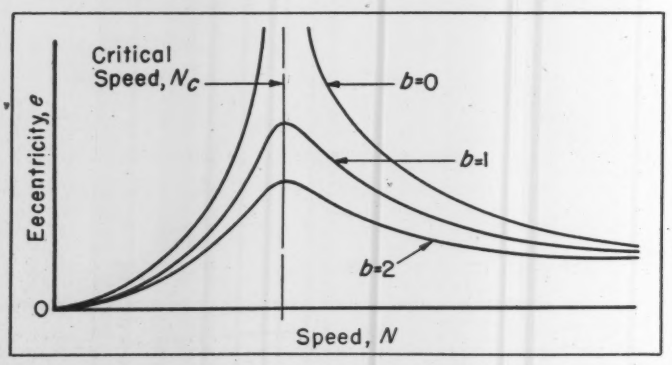
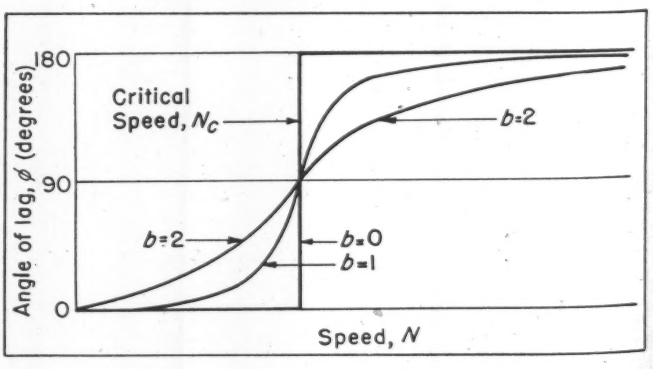


Fig. 3—Graph of angle of lag versus speed. Design of ideal automatic balancer must account for properties shown by this graph and that of Fig. 2



be as nearly as is possible in the same radial plane as the unbalance.

The purpose of this latter requirement is to minimize the horizontal reaction at the center of the elastic mounting of the rotating system. In *Fig.* 4, which shows the rotating system of an extractor as a free body, U is the force of unbalance, P is the compensating force exerted by the balancer and Q is the horizontal reaction acting in the plane of the elastic mounting. When the balancer has become effective, the sum of the moments of all forces about the point O must equal zero. Hence

$$aU - bP = 0 \quad \ldots\ldots (1)$$

$$P = \frac{a}{b} U \quad \ldots\ldots (2)$$

Also, the sum of all horizontal forces must equal zero. Hence

$$U + Q - P = 0 \quad \ldots\ldots (3)$$

$$Q = P - U \quad \ldots\ldots (4)$$

Substituting Equation 2 in Equation 4 gives

$$Q = \left(\frac{a}{b} - 1 \right) U \quad \ldots\ldots (5)$$

Equation 5 shows that $Q = 0$ only when $a = b$. Hence to minimize the horizontal reaction, Q, the balancing weights should be in a radial plane as near as possible to that of the unbalance.

LEBLANC BALANCER: As previously discussed and shown in *Fig.* 3, when an elastically mounted rotor such as *Fig.* 1 shows is unbalanced and is run above its critical speed, it may be said to rotate with its "light side out". Realizing this, Leblanc in 1916 suggested a simple automatic balancing device*. The general idea behind this device was probably anticipated by others†.

Description: The Leblanc balancer consists of simply a cylindrical chamber, *Fig.* 5, partially filled with a heavy liquid, such as tetrabromomethane with carbon tetrachloride. *Fig.* 5 shows this device in its most effective position surrounding the extractor basket. This places the balance correction more nearly in the plane of the unbalance, thus reducing the reaction at the pivot point O, as previously discussed. The basket is here shown deflected as it would be at some instant during rotation above the critical speed with no damping. For clarity the proportions of *Fig.* 5 are somewhat exaggerated.

The principle of operation of the device is as follows: Assume the rotor to be running at a speed above the critical, with no liquid in the balance chamber. Then, the rotor will run with an eccentricity or deflection, e, in a direction opposite to the unbalance, w. Under this condition, any liquid placed in the balance chamber will flow to the side of the chamber opposite the unbalance and will therefore tend to correct for the unbalance.

* United States Patent 1,209,730 dated 1916.
† See German Patent 10,629 dated 1879 and United States Patent 331,450 dated 1885.

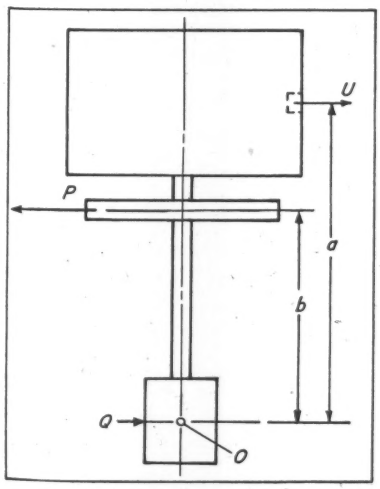


Fig. 4—Rotating system of extractor shown as free body

Corrects Only Part of Unbalance

However, this device cannot completely correct for the unbalance. If it did, the system would be rotating with its geometric axis O-O'' coinciding with its axis of rotation. The liquid would then distribute itself uniformly around the balance chamber, and there would be no correction.

Analysis: In the following analysis of the Leblanc balancer,

e = Eccentricity of rotation of center of gravity of basket and balance chamber
e_o = Value of e with no balance chamber
F = Resultant of accelerating forces on liquid in balancer
g = Acceleration due to gravity
h = Height of cylindrical balance chamber
k = Radial stiffness of elastic mounting of the rotating system, including balancer, as measured at center of gravity of basket
k_o = Stiffness of elastic mounting when no balancer is used
M = Weight of the balancing liquid
q = Radius of rotation of unbalance weight
r = Radius of free surface of balancing liquid
R = Outside radius of balance chamber
w = Weight of unbalance
W = Weight of basket, load, etc., and balancer
W_o = Weight of basket, load, etc., with no balancer
δ = Unit weight, or weight density, of balancing liquid
ρ = Radius of center of gravity of balancing liquid
ω = Rotative speed, radians per second
ω_c = Critical speed of system, radians per second.

Units of all of the foregoing quantities must, of course, be consistent.

In *Fig.* 5*b* are shown the accelerating forces acting on the basket, its load, and the balancing liquid. The force labeled $(W/g)\, e\omega^2$ is the product of the mass of the basket with its load and the acceleration of its center of gravity. Thus, this force is the resultant of all actual forces tending to accelerate the basket and load. Force F is the resultant of all forces tending to accelerate the balancing liquid.

In *Fig.* 5*c* are shown the forces exerted on the basket. The force labeled $(w/g)q\omega^2$ is the actual force

exerted by the unbalance on the basket, that is, the product of the mass of the unbalance and its acceleration. The force labeled *ke* is the equivalent restoring force of the elastic mounting on the basket, as though it were exerted at the center of gravity of the basket.

Because these two systems of forces shown in *Fig.* 5 are equivalent systems, they may be equated:

$$\frac{W}{g} e\omega^2 + F = \frac{w}{g} q\omega^2 + ke \quad \ldots\ldots (6)$$

The weight of balancing liquid, M, is given by the product of its volume and unit weight:

$$M = \pi(R^2 - r^2)h\delta \quad \ldots\ldots (7)$$

The radius to the center of gravity of the balancing liquid may be found by writing an equation of moments of weight about the axis O-O'. Thus,

$$\rho\pi(R^2 - r^2)h\delta = \pi(R^2 e - r^2 0)h\delta \quad \ldots\ldots (8)$$

The zero moment arm occurs, of course, because the free liquid surface is concentric with the axis of rotation. Solving for ρ,

$$\rho = \frac{eR^2}{R^2 - r^2} \quad \ldots\ldots (9)$$

Force F, which is the resultant of all forces tending to accelerate the balancing liquid, is given by the product of its mass and the acceleration of its center of gravity:

$$F = \frac{M}{g} \rho\omega^2 \quad \ldots\ldots (10)$$

Substituting Equations 7 and 9 in Equation 10 gives

$$F = \frac{\pi eR^2 h\delta\omega^2}{g} \quad \ldots\ldots (11)$$

This value of F may be substituted in Equation 6, giving

$$\frac{W}{g} e\omega^2 + \frac{\pi eR^2 h\delta\omega^2}{g} = \frac{w}{g} q\omega^2 + ke \quad \ldots\ldots (12)$$

Solving Equation 12 for the eccentricity, e,

$$e = \frac{wq\omega^2}{(W + \pi R^2 \delta h)\omega^2 - kg} \quad \ldots\ldots (13)$$

As the rotor passes through the critical speed, the balancing liquid is probably in a state of motion relative to the balance chamber, and would tend to dampen rather than to act like a mass fixed to the basket. Hence, in an estimate of the critical speed, the weight of balancing liquid will be neglected. Then, with no balancing action, Equation 13 becomes

$$e = \frac{wq\omega^2}{W\omega^2 - kg} \quad \ldots\ldots (14)$$

The critical speed would then occur when the denominator of Equation 14 is zero, or when

$$W\omega_c^2 = kg \quad \ldots\ldots (15)$$

Solving Equation 15 for ω_c,

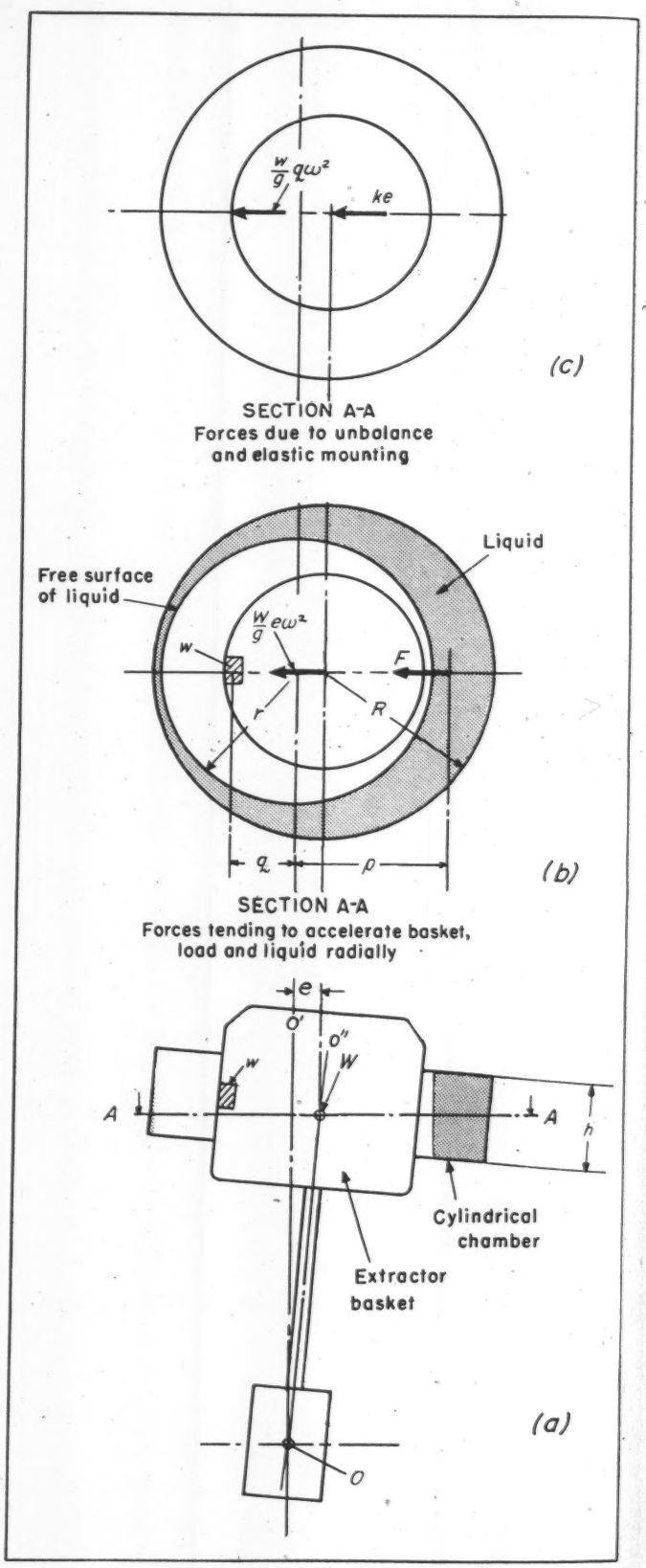


Fig. 5—Diagram of Leblanc balancer for typical operation above critical speed. For this state, liquid in balance chamber tends to correct unbalance

$$\omega_c = \sqrt{\frac{k\,g}{W}} \quad \ldots\ldots (16)$$

Equation 16 gives the critical speed of the rotating system under the condition that the balancing liquid

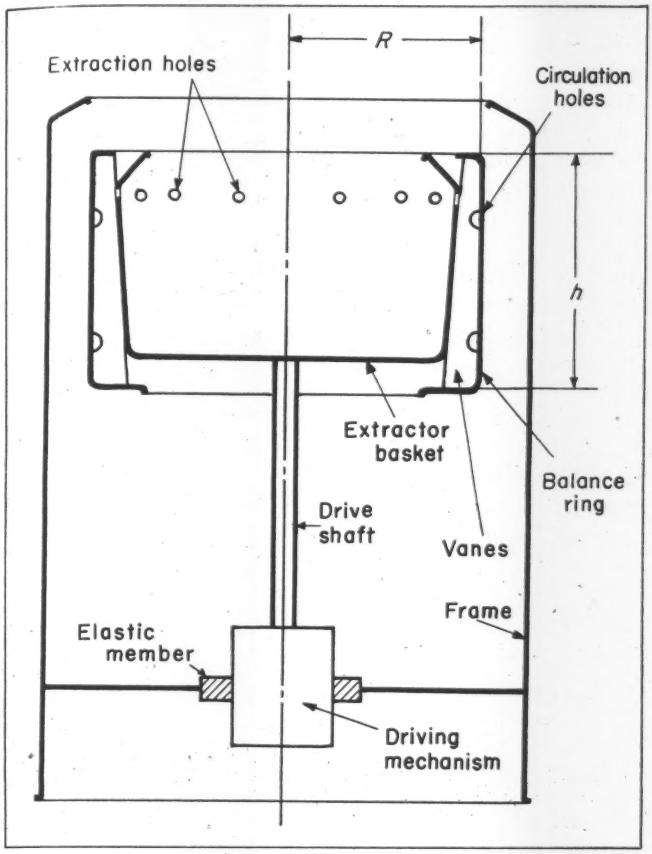


Fig. 6—Diagram of modified Leblanc balancer. Extracted liquid serves as balancing medium. Below critical speed minimum amount of liquid occupies balance ring

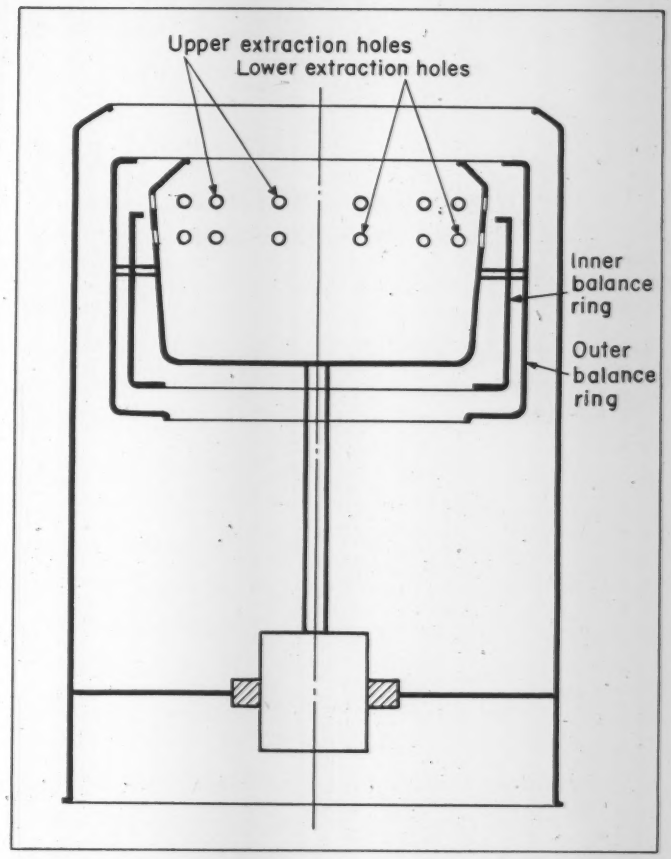


Fig. 7—Modified Leblanc balancer with two balance rings. Liquid from upper extraction holes passes into outer ring, from lower holes into inner ring

is not yet present at the outer radius of the balance chamber.

Examination of Equation 13 shows that below the region of critical speed the denominator and thus eccentricity, e, are minus. Hence, if balancing liquid is present, it reduces the magnitude of the negative denominator, acting to increase eccentricity and resulting vibration. That is, the unbalanced weight, w, and the center of gravity of the liquid, separated by less than 90 degrees for speeds below the critical, augment instead of counteract each other in their joint effect upon eccentricity.

MODIFIED LEBLANC BALANCER: Equation 13 suggests a modification of the Leblanc balancer. This modification‡ is simple, effective and inexpensive to manufacture. It consists simply of a flanged annular ring surrounding and attached to the basket in such a position that the extracted liquid enters the inside of this ring. This is shown diagrammatically in *Fig.* 6 in its simplest form.

The extractor basket is shown mounted on the driveshaft which extends upward from the driving mechanism. The driving mechanism is elastically mounted on the frame of the machine by means of an elastic member. The basket is perforated with holes through which the extracted liquid will flow.

Surrounding the basket and attached to it is a flanged annular ring known as the balance ring. The attachment may be made by studs or by axial vanes, as shown in *Fig.* 6. The vanes are perforated at their outer edges by holes to permit the balancing liquid to circulate circumferentially. The basket is here shown slightly tapered to conform more nearly to the free surface of the liquid in the balance ring and thus increase the effectiveness of the device at the lower speeds.

At low speeds, below the critical, little liquid is held in the balance ring, the amount of liquid present at these low speeds being determined by the width of the lower flange on the balance ring. As the speed increases and the extracted liquid flows from the extraction holes into the balance ring, more and more of this liquid is retained there and thus becomes effective in balancing the rotor. This design has the advantage that it uses the extracted liquid as the balancing means and minimizes the active amount of this liquid at speeds below the critical

Second Balance Ring Adds Effectiveness

A further modification of this balancer is shown diagrammatically in *Fig.* 7. Here a second balance ring is added, surrounding and concentric with the first one. Two rows of extraction holes are shown in the basket, one to supply liquid to the inner balance ring and one to the outer ring. This modification increases the effectiveness of the device.

Equation 13 applies also to the modified Leblanc balancer. With no balancer, Equation 13 becomes

‡ Patent pending.

$$e_o = \frac{wq\omega^2}{W_o\omega^2 - k_o g} \quad \ldots\ldots (17)$$

where

$$k_o g = W_o \omega_c^2 \quad \ldots\ldots (18)$$

The effectiveness of the Leblanc balancer may be calculated from Equations 13 and 17. Taking the quantity, $1-(e/e_o)$, as a measure of the effectiveness of the device, Equations 13 and 17 combined give

$$\frac{e}{e_o} = \frac{W_o\omega^2 - k_o g}{(W + \pi R^2 \delta h)\omega^2 - kg} \quad \ldots\ldots (19)$$

Substituting Equations 15 and 18 in Equation 19 gives

$$\frac{e}{e_o} = \frac{W_o\omega^2 - W_o\omega_c^2}{(W + \pi R^2 \delta h)\omega^2 - W\omega_c^2} \quad \ldots\ldots (20)$$

or, dividing by $W_o\omega_c^2$,

$$\frac{e}{e_o} = \frac{\left(\frac{\omega}{\omega_c}\right)^2 - 1}{\frac{W}{W_o}\left[\left(1 + \frac{\pi R^2 \delta h}{W}\right)\left(\frac{\omega}{\omega_c}\right)^2 - 1\right]} \quad \ldots\ldots (21)$$

The results of calculating the effectiveness of the modified Leblanc balancer from Equation 21 are shown in *Fig.* 8. Here the ratio of the eccentricity with the balancer active to that with no balancer, e/e_o, is plotted against the ratio of the speed of rotation to the critical speed, ω/ω_c.

In plotting Equation 21 in *Fig.* 8, the following assumptions were made:

Because the weight of the load continually changes as liquid is extracted from it, a mean value of weight of basket and load with no balancer is taken as W_o = 35 lb and a mean weight of basket and load with one balance ring as W = 43 lb.

The mean radius of a balance ring is assumed as R = 10 inches. When a single balance ring is used, the height of this ring is taken as h = 12 inches. When more than one balance ring is used, the value of h used in Equation 21 should be the sum of the heights of the rings. Thus, with two balance rings, the effective height is taken as h = 20 inches. Also, with two balance rings the weight of the rotating system will be somewhat greater. Hence, in this case it is assumed that W = 50 lb.

As shown in *Fig.* 8, a single balance ring is quite effective, reducing the eccentricity of rotation of the basket above the critical speed to less than 20 per cent of what it would otherwise be. The device is therefore more than 80 per cent effective. These curves also show that the second balance ring may be worth the added complication.

Any interpretation of Equation 21 at speeds near or below the critical speed is likely to be meaningless and should therefore be made with extreme caution.

CONCLUSIONS: Comparing results of this study with the four requirements of the ideal balancer leads to the following conclusions on the Leblanc balancer and its modifications:

1. Because their function requires a certain "residual" unbalance, they cannot be completely effective
2. The unmodified form aggravates unbalance at speeds below and near the critical and thus does not help the rotor pass through this speed. In the modified designs, this fault is reduced
3. Although not completely effective at speeds above the critical, they do greatly improve the operation of extractors at high speeds
4. Lending themselves nicely to placement of the balance correction near the plane of the unbalance, they provide for minimum horizontal reaction at the elastic mounting.

In certain applications the latter two features of the Leblanc-type balancers may more than compensate for their lack of complete effectiveness.

Among other approaches to the problem of obtaining automatic balancing are those involving mechanical means. These systems will be discussed in the next article of this series.

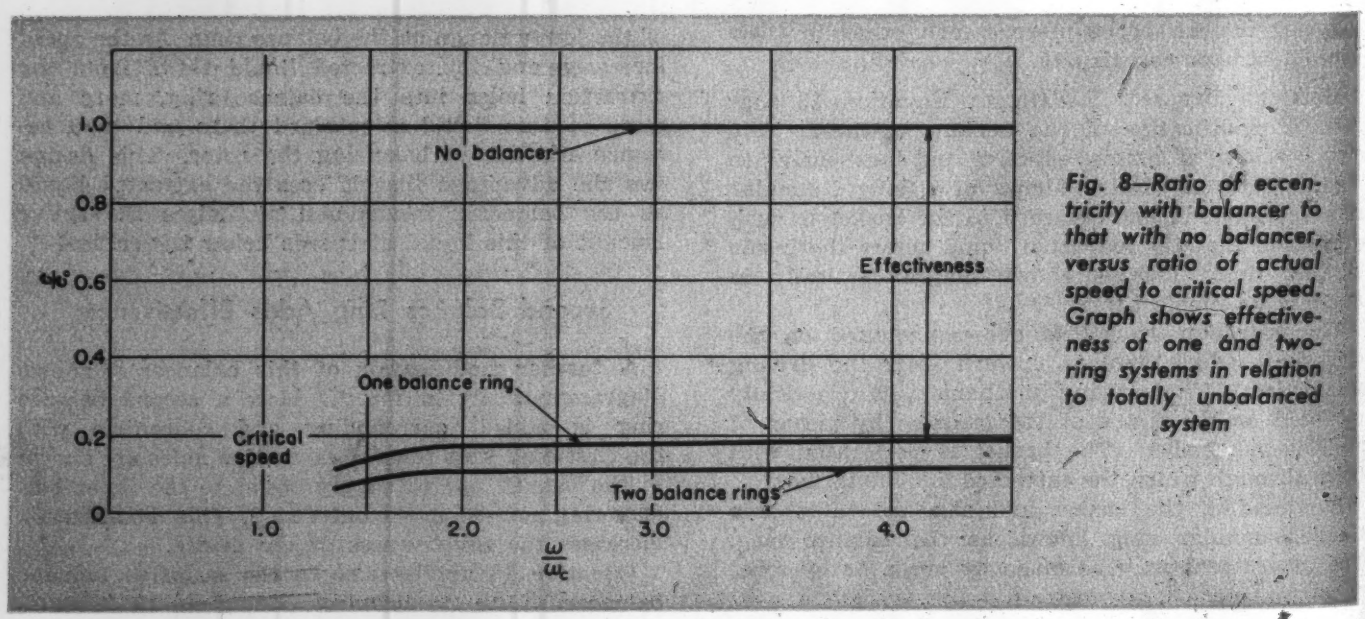


Fig. 8—Ratio of eccentricity with balancer to that with no balancer, versus ratio of actual speed to critical speed. Graph shows effectiveness of one and two-ring systems in relation to totally unbalanced system

Built-In Motors

. . . give improved performance at low cost

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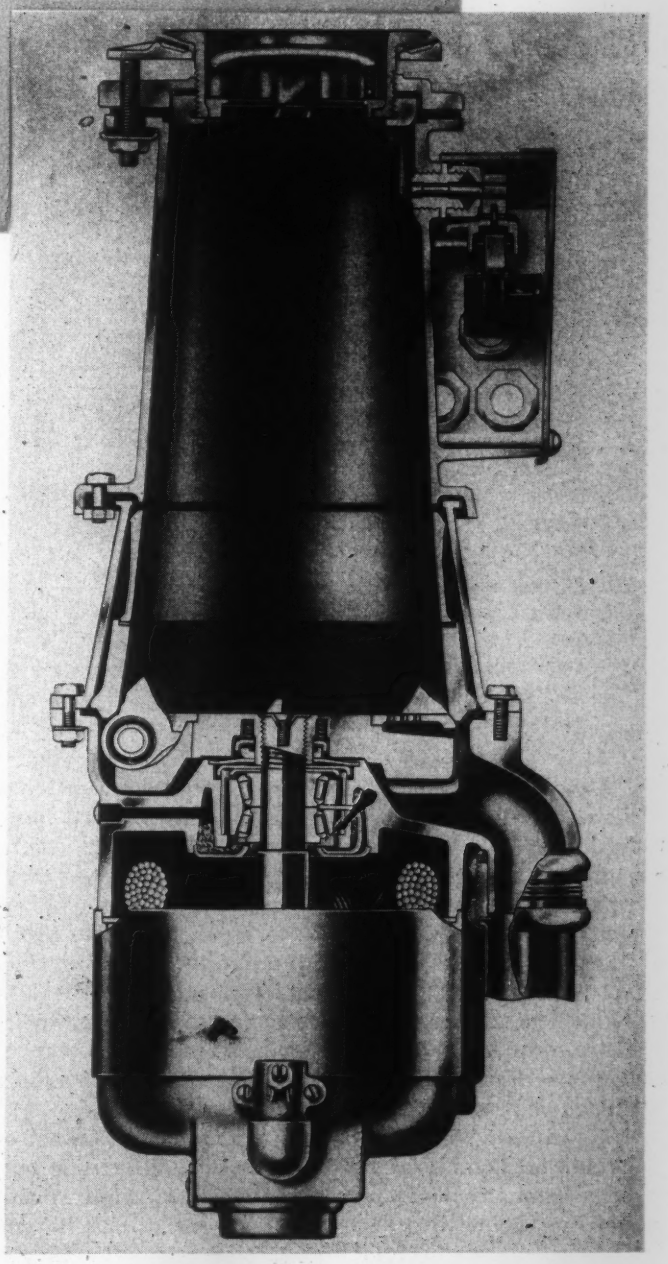

Fig. 1—Motor, grinding head and hopper assembly for garbage disposal unit. In this typical application of built-in motors, heat loss is shared by circulating air and processed waste

UNTIL comparatively recent years, it was considered below the dignity of a qualified engineer to devote his time and skill to small mass-produced motor-driven machines. Careful analysis, ingenious design, and patient tests were the exception; a quick mock-up, a hasty test, and patched-up changes, the rule. This was on the theory, in many cases, that the product was expendable and the market transient. However, as the demand has matured and stabilized, the business in such machines has grown to startling unit and dollar totals.

More important for our present purpose, good engineering design has changed from a luxury to a necessity. This is further pointed up by the fact that most of these machines are now in applications important to the customer, with considerable convenience, monetary risk, or even safety, depending on their correct operation. Consider, for instance, a hospital oxygen-tent pump, a railway-track switch, or the compressor for a frozen-food locker plant. Even frequent repetition cannot overemphasize the axiom that satisfactory field performance depends critically upon good design, materials, and workmanship. This salient truth is feelingly supported by every manufacturer who has gone through the headaches, losses, and temporary customer disgust in reaching a good field reputation.

When an engineer first faces the problem of designing his machine, he usually can choose between conventional motor drive and integral or "built-in" motor drive. The determining factors are:

This article is based on a paper presented at a session of the Machine Design division of ASME at the Semi-Annual Meeting, St. Louis, June 19-23, 1950. Complete paper appears in *Mechanical Engineering*, August, 1950, pages 615-628.

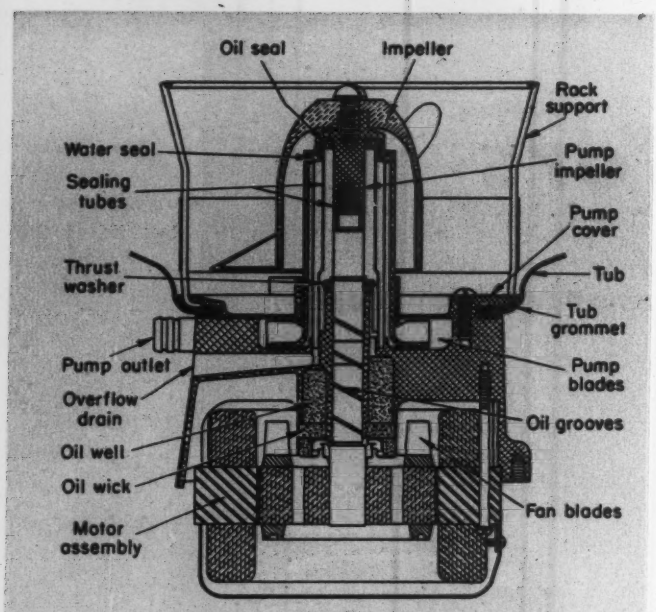

Fig. 2—Motor, pump and impeller assembly for dishwasher. Motor heat is lost to air circulated by rotor fan

Conventional Motor

1. Motor and starting accessories guaranteed by motor vendor
2. Motor service replacement simple
3. Quantity may be in medium or low production
4. May mount load element on motor shaft if uncomplicated
5. Benefits by large production of general-purpose types.

Integral Motor

1. Lowest cost when all tooled
2. More compact
3. Fewer parts
4. Fewer bearings
5. Simpler mountings
6. Safer
7. Requires knowledge of good motor practice.

Many motor manufacturers prefer conventional motor applications because in that way they have more control over the variables. However, where justified, the integral-motor design yields the best performance and the lowest cost.

It is the purpose here to set forth the basic properties of motors as applied to built-in mechanisms. To limit the field, the integral-motor mechanism is defined in the following terms: single function, self-contained, high duty factor, mass produced, fractional or low integral horsepower motor, and motor structure provided by driven mechanism.

In any selected case, minor variations of the foregoing characteristics may appear, but the major features should correspond. Practically all built-in motors are below 5 hp or even 3 hp because in larger sizes the motor weight and size so dominate the design, and production is generally so limited that "building-in" is practically never economical.

The lower power limit is assumed to be 1/50-hp. Below this value the motor is generally not for power-conversion purposes, but for timing or torque and efficiency is not important. In these latter cases design merit is judged on cost, size, simplicity, or some combination rather than performance primarily.

MECHANISM TYPES: The following assumptions are made on the basis that high quality, "engineered" mechanisms are under discussion:

1. Substantially no wear (rated life is in 1000's or 10,000's hr)
2. Practically no failures (high safety factor)
3. Lifetime lubrication
4. Lowest ultimate cost (quantity high enough for adequate tooling)
5. Industry standard motor components (used with limited exceptions).

The assumptions are selected to limit the discussion to those products which are carefully designed, redesigned, tested (both in laboratory and field), tooled, and finally produced with the expectation of contributing to the art and staying in the business.

Mechanisms will be classified according to method of cooling because that characteristic is probably the most influential in basic design. Usually the motor is the greatest source of heat, because it is the first element in the line of power transformations. Also, its efficiency is ordinarily no greater than that of subsequent components.

Three classes are listed as follows, together with a few illustrations of representative devices:

1. Conduction-cooled: Heat loss shared by circulating air and pumped fluid or metallically conducted to adjacent dissipator. Garbage disposer, pump, blower.
2. Convection-cooled: Heat lost to air circulated by rotor fan. Food mixer, gear reducer, vacuum cleaner.
3. Liquid-cooled: Core and windings in heat-dissipating contact with lubricant. Refrigerator, transformer oil circulator, automatic washer.

Examples of these three classes are shown in the same order in *Figs.* 1, 2 and 3.

The fully sealed or hermetic mechanism such as shown in *Fig.* 3, approaches the ultimate in reaching good engineering objectives. Where justified, this design is: quietest, safest, most tamperproof, most rugged, smallest (with a given type of motor), best lubricated and best protected from environment. In addition, such a mechanism can benefit by internal hydraulically operated auxiliaries, where needed.

CLASSES OF AVAILABLE MOTORS: The preferred available motors are:

1. Split-phase: Induction motor with high-resistance start winding. Centrifugal switch cuts start winding out of circuit at 60-80 per cent full speed
2. Capacitor start: Induction motor with low-resistance start winding and high value (approximately 150 mfd) electrolytic capacitor in series. Very high starting torque. Centrifugal switch operated as in split-phase type
3. Two-value capacitor: Induction motor with slightly better power factor and higher efficiency than capacitor-start type, but starts the same way
4. Repulsion-induction: Induction motor having a wound rotor overlying a squirrel cage which is deep in the slots. Two short-circuited brushes

(per pair of poles) are in contact with the commutator during start. The wound rotor starts in a manner similar to a series motor, except that the rotor current is induced instead of direct-connected. The squirrel cage is not active during low speeds due to flux leakage between rotor teeth. The brushes stay in contact all the time, and the squirrel cage acts as a motor below synchronous speed and as a brake over synchronous speed. The second effect keeps the no-load speed to about 125 per cent of the synchronous value

5. Polyphase: Typical 2 or 3-phase motor. High inherent starting torque. No start windings, as such
6. Shaded pole: Induction motor with starting torque provided by delaying the flux at one edge of the pole tip. This phase change corresponds to the extra magnetic field provided by the conventional start winding and results in a unidirectional starting torque. This motor has low starting torque, but is low in cost and good for fan-type loads
7. Permanent split capacitor: Induction motor with start winding permanently connected through a long-life series capacitor (approximately 5 mfd) to the line. No starting mechanism
8. Series (universal): The field coils and wound rotor (through commutator and brushes) are in series. Torque results from reaction of two independent magnetic fields, having a constant angular relation determined by brush location. Operation on alternating current changes the performance only slightly from that on direct current. Not satisfactory for operation in a sealed mechanism due to commutator.

Within any given class, the motor designer has certain latitudes, aside from size. First he chooses the number of poles, leaning toward fewer poles when choice is possible. Then comes frame size. NEMA* has standardized on both outside and rotor bore diameters but usually a given horsepower can be put in at least two frame diameters, using long and short stacks. Especially at this point the motor customer can influence the design to his best advantage. Following these come the other usual parameters: number of slots (2 or 3 standard arrangements per frame size), stack height, coils per pole and per phase, turns per coil, and wire size.

Of this list, the variables most easily handled (and changed) are stack height, coil turns and wire size. Recent references on motor design are listed at the end of the article.

MOTOR PROPERTIES: The following brief analysis explains the shape of the torque-speed curve for induction motors and hence shows how the need arises for start windings on single-phase induction motors.

By means of the widely used "revolving-field" theory, the output of a single-phase motor can be derived as follows:

$$T = 113 \frac{I^2}{N} \left(\frac{R_2^+ - R_2^-}{2} \right)$$

where T = output torque, oz-ft; I = line current, amp; N = synchronous speed, rpm; R_2^+ = equivalent series resistance of load referred to stator, forward field, ohms; and R_2^- = equivalent series resistance of load referred to stator, backward field. Several of the listed references outline the procedure for evolving this equation from the motor characteristics.

* National Electrical Manufacturers Association, 155 East 44th Street, New York.

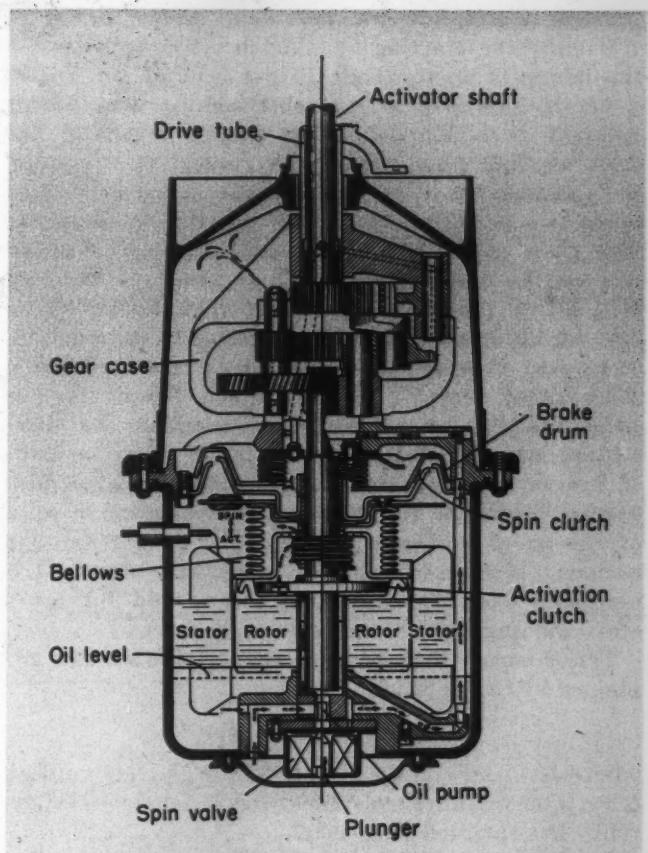

Fig. 3—Motor, clutch and gearing assembly for automatic washer. Heat is dissipated by contact with lubricant

Torque is shown plotted against speed in *Fig.* 4. The curve has been extended in the reverse direction to show the polar symmetry of torque for the run winding operating alone in either direction. As may be seen, the run winding has no torque at standstill, or even appreciable torque up to ¼ speed in either direction.

When a second pulsating magnetic field is added to the foregoing, displaced both in time phase and physically 90 electrical degrees in space, the resultant is a single rotating field, as with a polyphase motor. This changes the single-phase motor to a polyphase motor, with the resulting high starting torque. This second field is always supplied to start single-phase induction motors (except repulsion-start types).

Phase shift of this auxiliary field is obtained either by higher-than-normal resistance in the start winding, series capacitance in the start winding, or by a shading coil on the pole face. Lower-than-normal resistance cannot provide enough phase change. This shading coil is a very low resistance short-circuited turn around a portion of the pole flux, resulting in a time delay or phase shift of the encircled flux. This is equivalent to the second-phase field. The torque

curve is modified to the dotted line shown in *Fig.* 4.

Usually the starting winding is disconnected when the motor is up to about 75 per cent of full speed. Generally this is done by a centrifugal switch. Motor reversal is accomplished by simply reversing the start winding connections with respect to the main. With ordinary low-inertia loads the motor gets up to speed in less than 1 sec, so the starting winding has very short duty. As a consequence, the current densities may be designed very high and the wire becomes both small (economical) and of high resistance as desired, although then it is vulnerable to burning out. The usual general-purpose motor of this type has a 3-sec rated starting period; much longer periods cause the wire to overheat the insulation. As alternatives, where indicated, start windings may be made of bronze wire for higher resistance, and Fiberglas-varnish insulation for greater heat resistance, in place of the usual synthetic enamel. For longer starting periods (high inertia loads) a starting capacitor is necessary both for increased torque and for lower start winding and line currents.

Series-motor torque-speed characteristics are explained by the equation:

$$NT = K_3(V - IR)I$$

where N = speed, K_3 = constant, V = line voltage, R = total machine resistance, and I = current. Current I is a function of speed N.

If the right-hand side of the equation were constant, the expression would represent an equilateral hyperbola in speed and torque. The variance of I, small at high speed and vice versa, modifies the hyperbola as shown in *Fig.* 5. It is obvious that no special starting arrangement need be provided for series motors.

TABLE 1 presents a list of properties compiled from motors in production. It may be used for comparison and reference of all properties of interest to the motor user and may be of help in original selection of class.

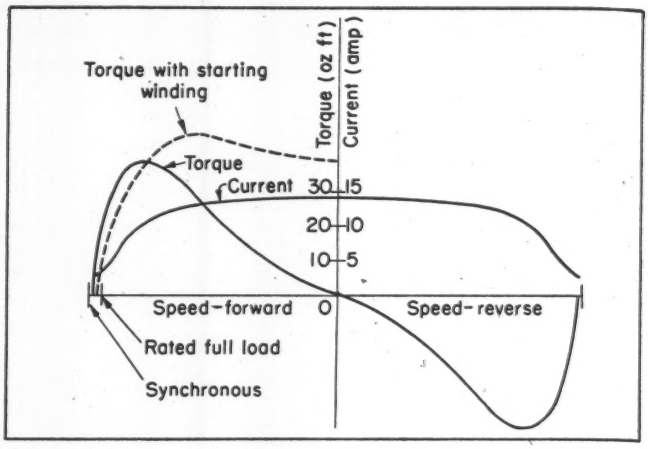

Fig. 4—Graph of torque and current versus speed with run winding only for single-phase, induction motor, based on "revolving-field" theory. Dashed curve represents torque as modified by addition of a starting winding

Not enough data are presented to draw curves versus rating, but trends can be noted. For example, the ratio of maximum torque to full-load torque is surprisingly constant near 2.5 over the family of single-phase induction motors.

Standards have been established by NEMA covering basic performance characteristics including breakdown torque, starting torque, and starting current. Elective properties are, in general, ratio of starting to full-load torques, efficiency, and power factor.

CONCLUSION: Building a motor integrally into a mechanism achieves practically all ideal application objectives. The single-phase induction motor is a simple, sturdy, adaptable prime mover for constant-speed loads, but proper motor application involves many factors which require extensive knowledge, skill, and experience. These conclusions seem especially true and pertinent in the design of mech-

Table 1—Typical Properties of Alternating-Current Motors

Class	Rating (hp)	Typical full-load speed (rpm)	Efficiency (per cent) Full load	Efficiency (per cent) Maximum	Power factor (per cent) Full load	Power factor (per cent) Maximum	$\frac{T_{max}}{T_{fl}}$	$\frac{T_{stg}}{T_{fl}}$	$\frac{I_{stg}}{I_{fl}}$	Reversibility
Resistance split-phase induction	1/40	1725	40	45	54	75	2.6	2.4	6.2	Not instantaneously reversible
	1/6	1725	64	65	66	83	2.5	2.0	7.15	
	1/3†	1725	62	62	63	84	2.8	2.2	8.0	
	1/3	3450	75	76	72	89	2.9	2.0	7.5	
	1/6	1140	57	59	59	77	2.2	1.8	6.0	
Capacitor start-induction run	1/6	1725	62	64	64	87	2.9	4.9	5.75	Not instantaneously reversible
	1/2	1725	73	74	74	84	2.6	4.5	5.0	
	1	3450	73	73	73	86	2.5	2.4	4.7	
	1/2	1140	71	72	57	74	2.5	3.3	4.75	
Permanent split capacitor	1/6	1620	65	65	85	90	2.4	0.55	3.5	Instantaneously reversible
Shaded-pole induction	1/20	1550	29	29	62	62	1.35	0.35	1.5	Not reversible
	1/12	1050	30	30	58	58	1.30	0.37	1.5	
Repulsion induction	1/6	1725	58	61	61	76	2.4	4.7	2.5	Not instantaneously reversible
	1/2	1725	61	65	55	73	2.8	4.7	2.75	
	1/2	3450	55	56	88	92	2.3	3.8	4.25	
Polyphase induction	1/6	1725	70	74	72	92	4.5	3.8	6.85	Instantaneously reversible
	1/3	1725	78	78	78	91	3.9	3.3	7.3	
	1/2	1725	75	75	75	91	4.3	3.0	7.45	
	1/3	3450	75	76	81	92	4.1	3.4	7.4	
	1/6	1140	68	72	56	86	4.3	3.6	5.0	
Series	1/50 to 2	5000 to 17500	25 to 80		85 to 95		T_{max} occurs at starting	T_{fl} depends on ventilation	Depends on rated condition	Usually not reversible

† Short hour duty rating.

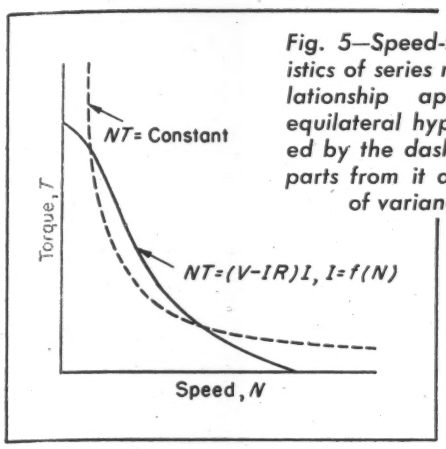

Fig. 5—Speed-torque characteristics of series motor. Actual relationship approximates the equilateral hyperbola repersented by the dashed curve but departs from it as shown because of variance in current

anisms where the product engineer must assume responsibility for the motor and its starting accessories.

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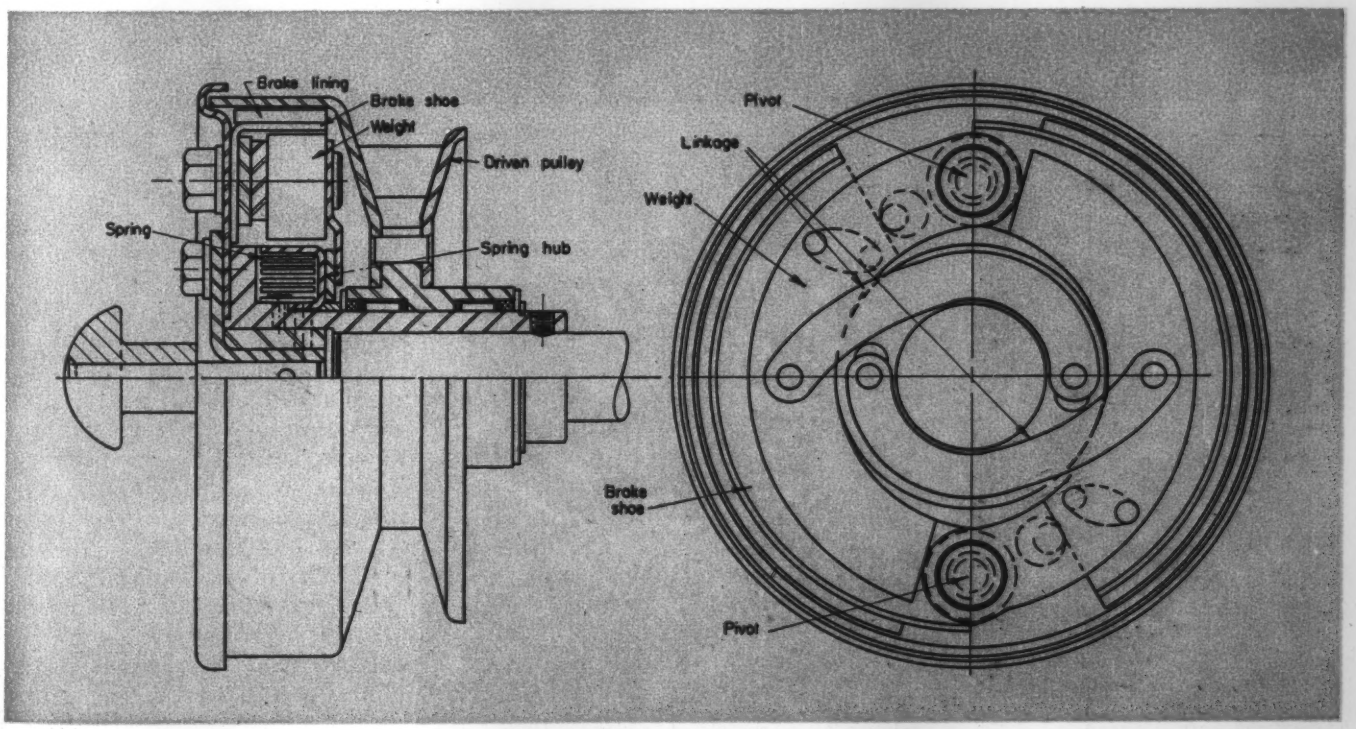
Clock Type Spring Controls Clutch

A CLOCK type tension spring actuates the centrifugal clutch, below, designed by Dodge & Stevens Inc., Rockford, Ill. Two brake shoes, such as are used in automobiles, are pivoted on an assembly attached to the drive shaft, the same pivot points being used for mounting two brake shoe weights. These weights are linked to a drum surrounding the spring. Spring force rotates the drum slightly and holds weights and shoes in their retracted positions at zero speed.

In operation, centrifugal force throws the weights out against the brake shoes, engaging the clutch by counteracting the effect of the tension spring. When the driveshaft slows down, the spring retracts the weights and shoes to disengage the clutch. If the linkage is adjusted to the dead center position, the clutch is locked out.

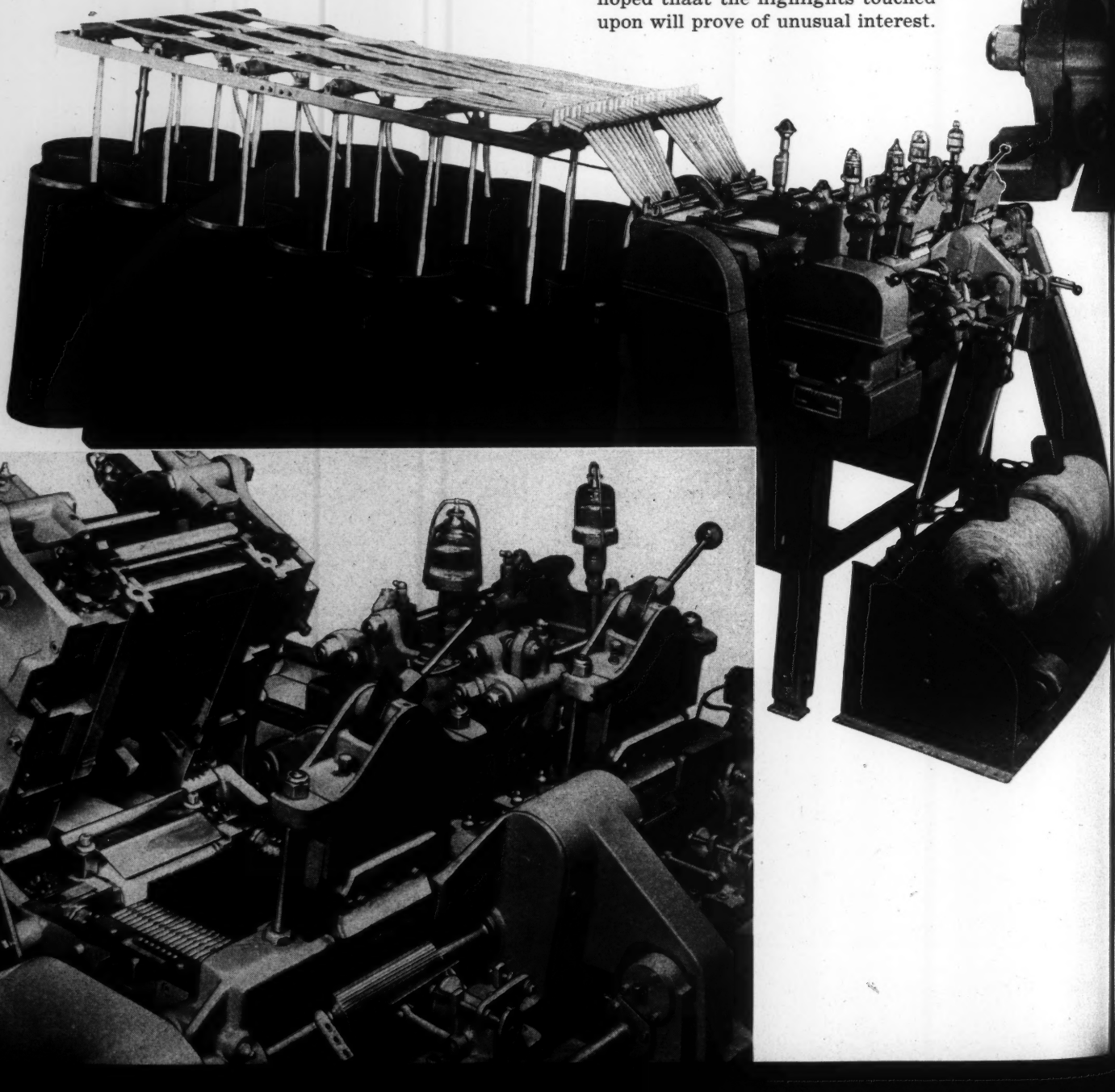


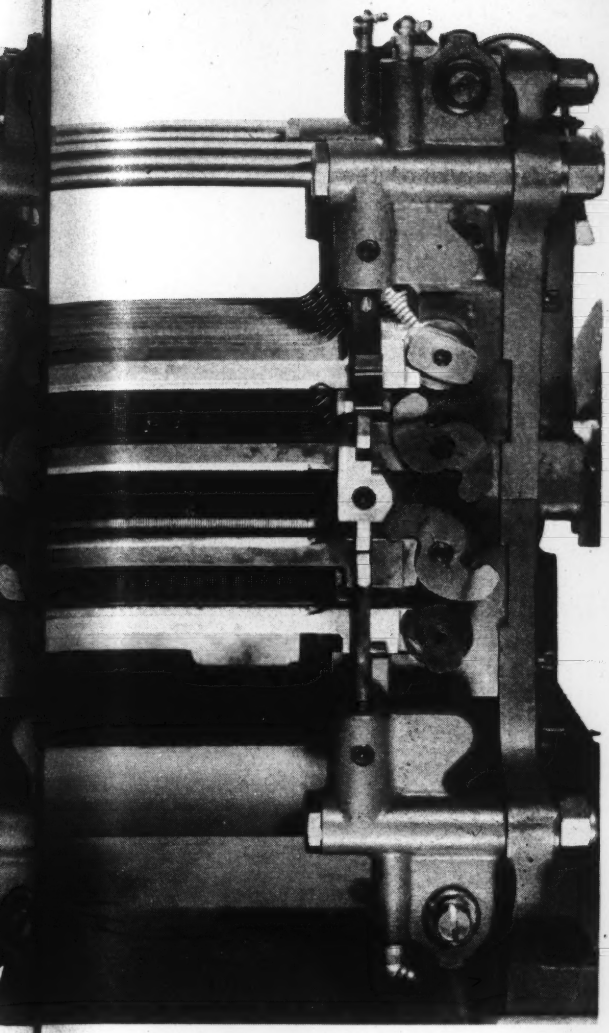
Contemporary DESIGN

Textile Machinery

DURING recent years textile machinery has seen tremendous advancements in design. Many problems of design in this field are unique; others are common to many areas of machine design. Because the practical solutions to unique or common problems in one field can often spark the creative trend of thought toward practical answers to unrelated problems in other fields, MACHINE DESIGN is presenting this pictorial review of the most recent innovations in the textile field.

The largest textile machinery exhibition ever held took place in Atlantic City during the week of May 8 to 12, 1950. From this ideal vantage point the accompanying review has been garnered in detail. Such a review can in no way be complete but it is hoped thaat the highlights touched upon will prove of unusual interest.





Pin Drafter Has Screw Drive

A REFINED version of a screw gill adapted to yarn processing, the Warner & Swasey Pin Drafter is designed for drafting operations prior to roving on straight wool or blends of wool, wool and synthetic cut staple, and 100 per cent synthetic cut staple. Stock flows into the machine from can or ball creel through sliver guides and stop motions to weighted feed rolls, onto the splicing or conveyor belts and then through the faller section to the draft rolls, folder and can or balling unit.

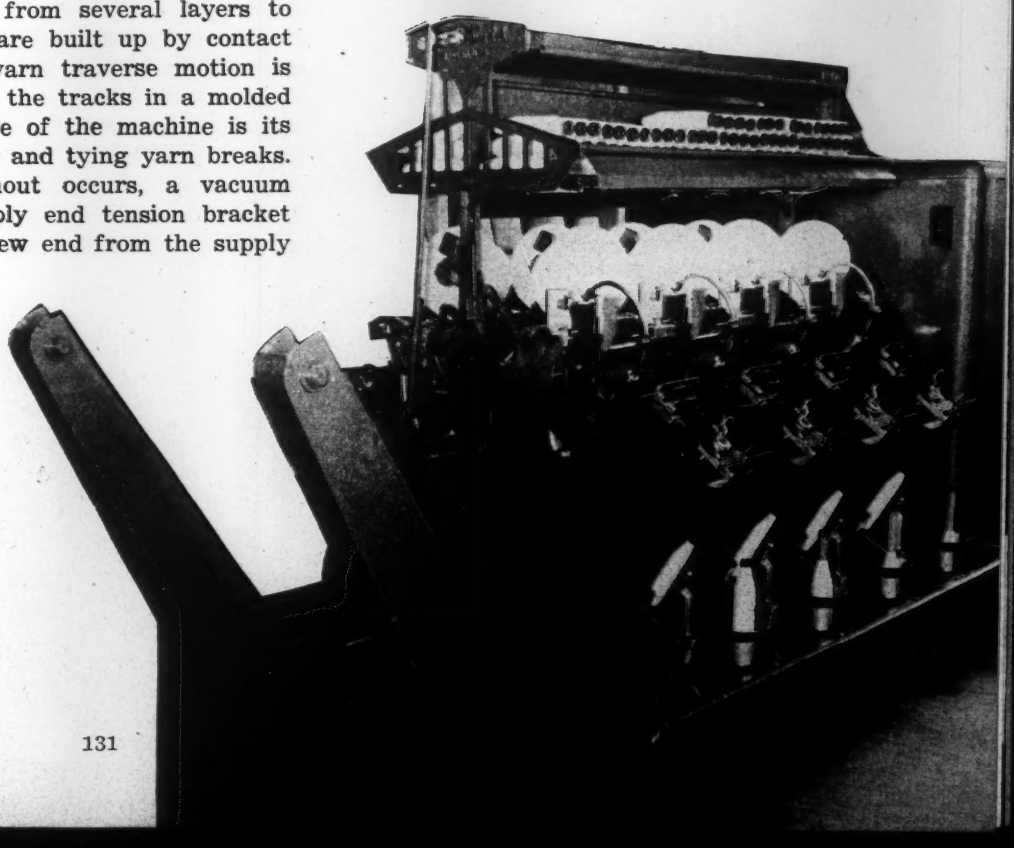
View of the left faller section opened shows the construction. Faller bars use flat pins soldered into a milled U-slot with 15 to 34 pins per inch. Feed through the faller section is approximately 9 yards per minute. Speed of the 5/16-inch pitch screws driving the faller pin bars is 515 rpm resulting in 1030 faller drops per minute. Cams at the front, in conjunction with the screws, transfer the faller bars continuously in a rectangular path. Second closeup shows the delivery end of the faller section with feed screws, faller bars, cams, and conductors.

Auto-Coner Features Automatic Knot Tying

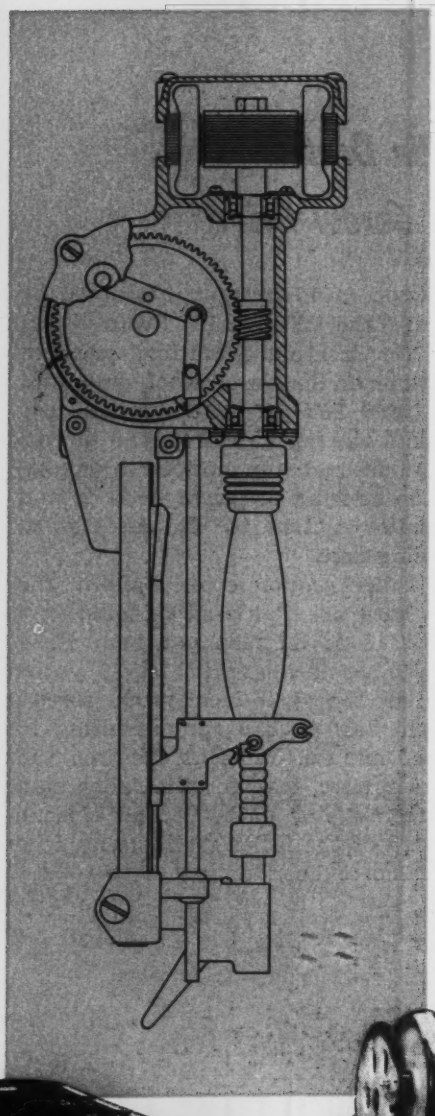
ALMOST entirely automatic in function, the Auto-Coner by Universal Winding Company is a drum winder capable of winding cone packages from several layers to a 9-inch diameter. Cone packages are built up by contact rotation on a pair of rolls. The yarn traverse motion is created directly by feeding through the tracks in a molded plastic traverse cam. Unique feature of the machine is its automatic mechanisms for retrieving and tying yarn breaks.

Whenever a yarn break or runout occurs, a vacuum tension nozzle swings into the supply end tension bracket and picks up the broken end or a new end from the supply bobbin. Simultaneously, a package end nozzle retrieves flying end from the cone and places it into the knotter by means of an ejector. Once the ejector has deposited the package end, the tension nozzle deposits its end, the knot is mechanically tied, the tails clipped, and the waste sucked away.

Upper of the two supply bobbins at the foot of the machine is swung into active position whenever the lower active supply runs out. The empty bobbin is automatically ejected onto a conveyor belt.

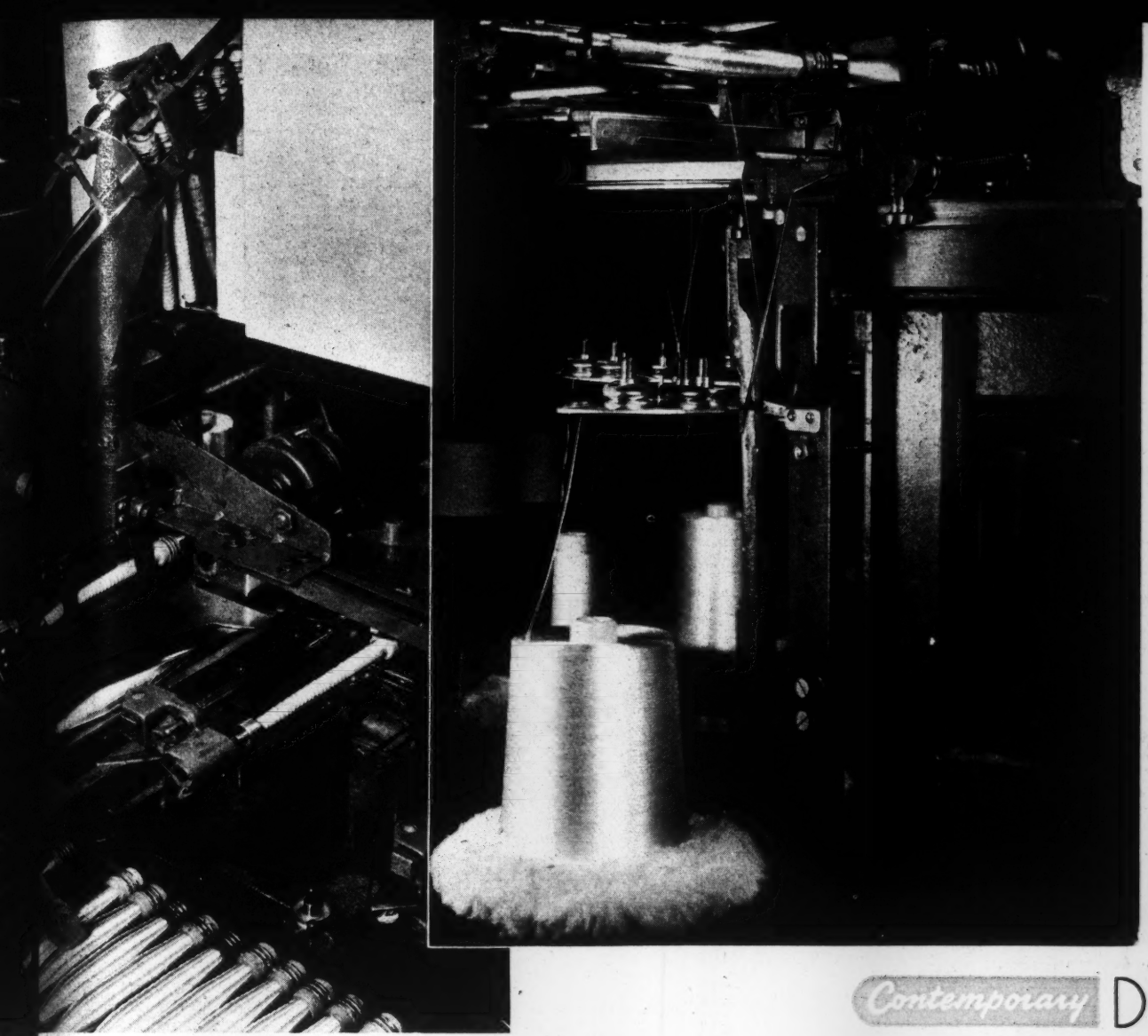


Quiller Automatically Loads and Winds



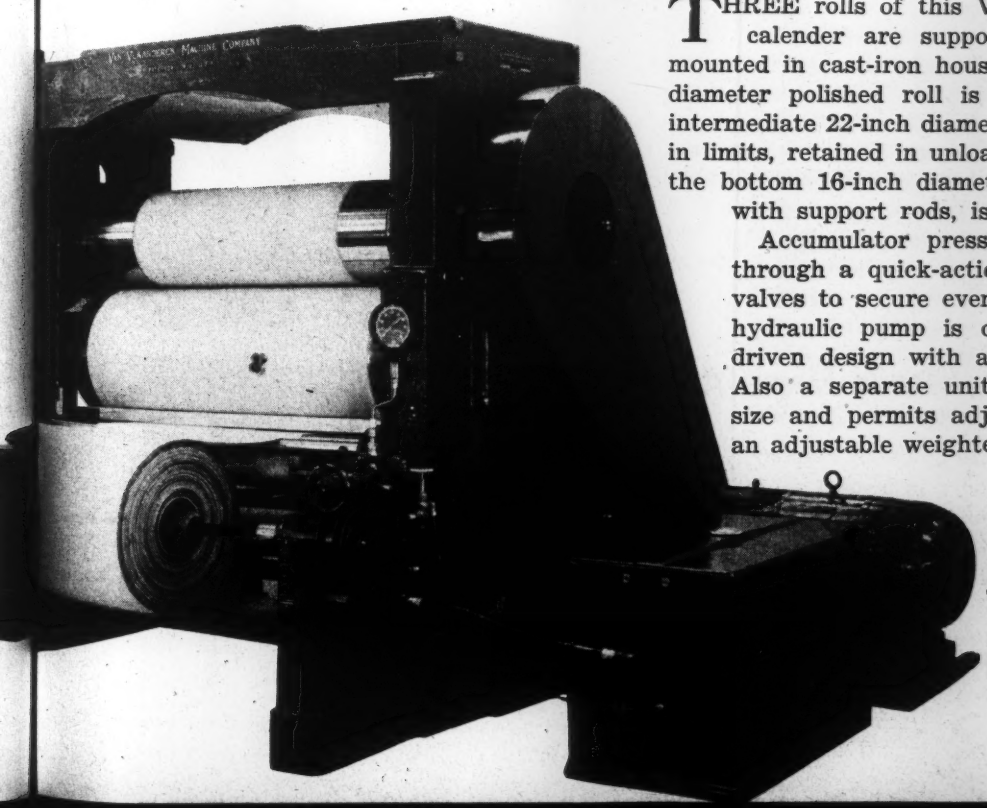
FULL automatic operation with a single automatic head is the principal feature of the Abbott Machine Company's filling winder. Bobbin spindles are self-powered and travel around the machine, winding one bobbin each circuit. The one automatic head resets the thread guide at the start, changes the bobbins, cuts the end from the bobbin wound, and starts the new one.

Each traveling spindle has only four moving parts. A double-throw cam is driven from the motor spindle through a worm and worm wheel and creates by means of linkage the traverse motion of the thread guide. A chain carries the units around the stationary track and an overhead track serves as a master cam for the thread guide to cover properly the entire bobbin. Chain speed is variable and a simple knock-off motion stops the spindle motor on any unit whenever the yarn breaks or a bobbin is full.



Contemporary DESIGN

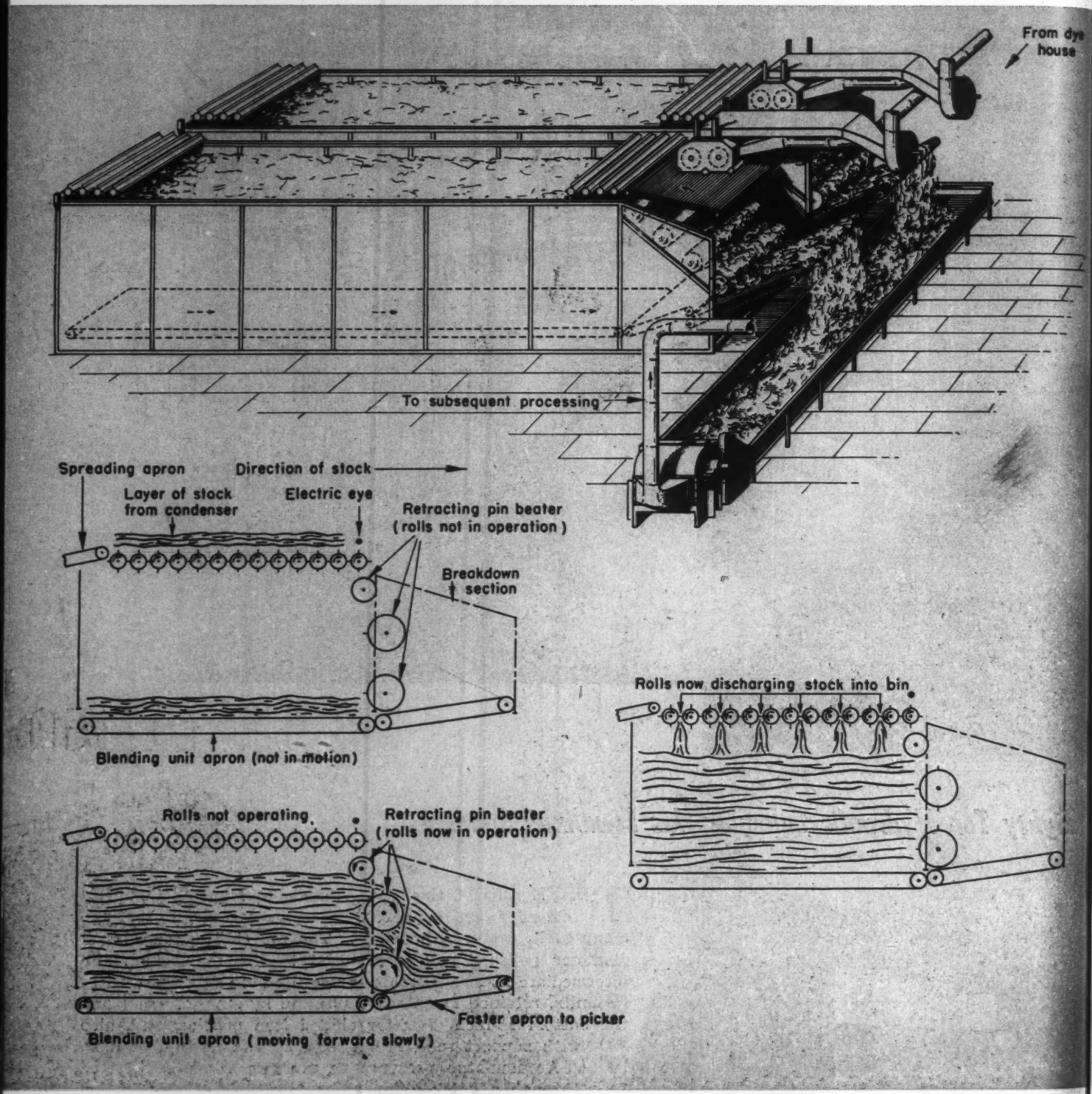
Eighty Ton Hydraulic Calendar Has Equalized Loading



THREE rolls of this Van Vlaanderen Machine Company calender are supported in spherical roller bearings mounted in cast-iron housings. The top chilled-iron 20-inch diameter polished roll is fastened to the top frame; the intermediate 22-inch diameter pressed cotton roll floats within limits, retained in unloaded position by support rods; and the bottom 16-inch diameter chilled iron polished roll, also with support rods, is actuated by two hydraulic rams.

Accumulator pressure to the two rams is directed through a quick-action valve to a pair of equalization valves to secure even roll movement and loading. The hydraulic pump is of a special three-plunger crank-driven design with a direct-connected gearhead motor. Also a separate unit, the accumulator is of generous size and permits adjustment of pressure by means of an adjustable weighted lever pressure control.

A reservoir for a circulating oil system is built into the top framework and feeds oil continuously through the roller bearings, to an oil cooler and pump sump where the oil is filtered and pumped back to the top reservoir.


From dye house
To subsequent processing
Spreading apron
Direction of stock
Layer of stock from condenser
Electric eye
Retracting pin beater (rolls not in operation)
Breakdown section
Blending unit apron (not in motion)
Rolls now discharging stock into bin
Rolls not operating
Retracting pin beater (rolls now in operation)
Faster apron to picker
Blending unit apron (moving forward slowly)

Blends Fibers Automatically

FOR evening out of shades following batch dyeing operations and for blending fibers in almost any type of mill operation, the Proctor & Schwartz Inc. roller distributor is one of the newest units developed for automatic operation. A layer of stock is fed from a spreading apron across a series of rolls operating in the same direction. When the stock has reached the last roll an electric eye actuates reversal of alternate roll rotation to discharge the stock into a bin or blending area.

Bin or storage feed is equipped at the discharge end with a breakdown section for delivering the blended stock and giving further blending. Receding pin rolls slice down the pile of stock from top to bottom and discharge to a picker or to conveyors for subsequent processing.

High-Speed Narrow Fabric Weaving Machine

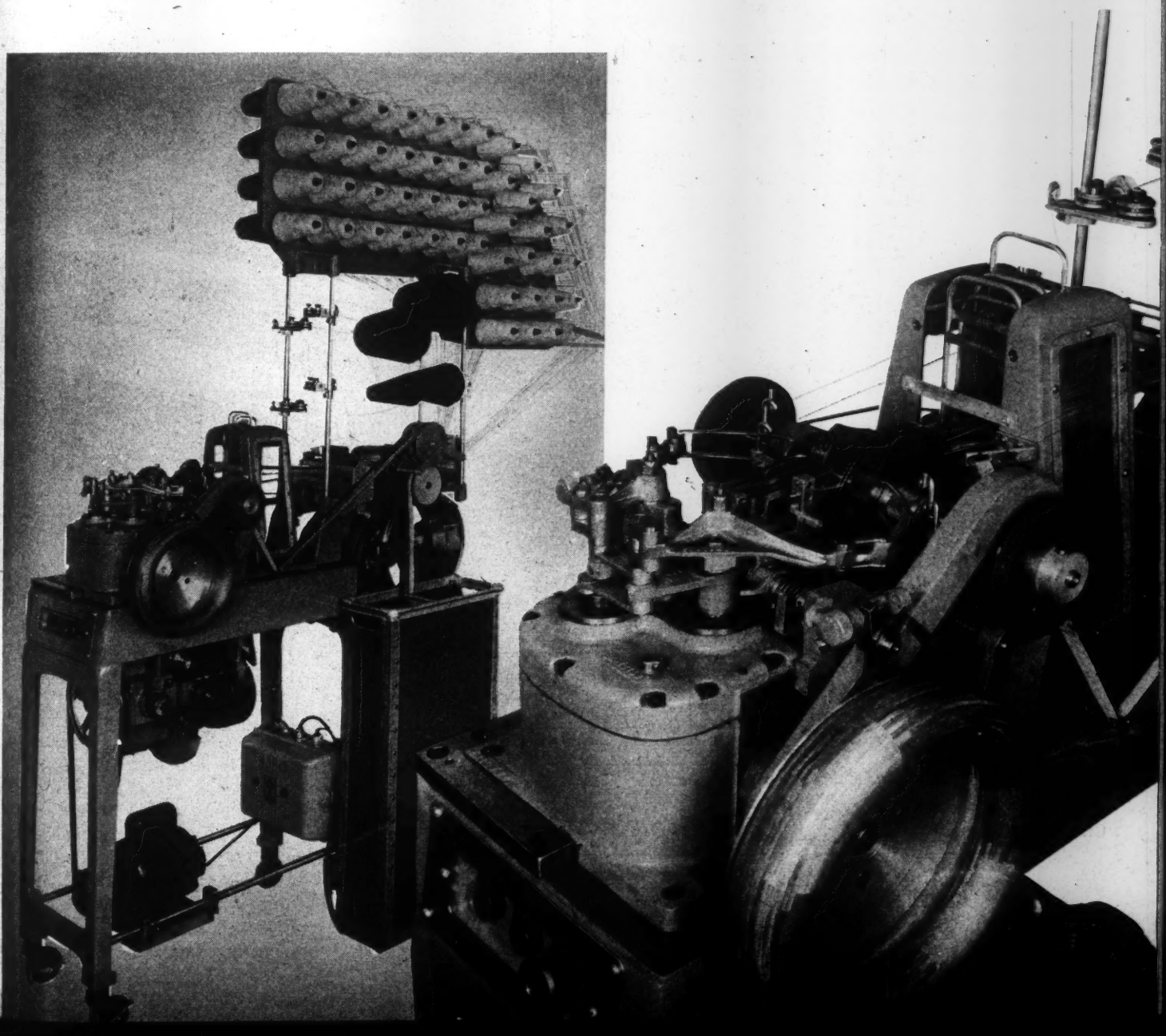
DESIGNED to weave with filling drawn from large cones of yarn, this needle loom built by Crompton & Knowles Loom Works utilizes a rotary reed in which groups of warp ends always remain in the correct reed dent. The fabric has two picks in each shed and alternate filling loops at each edge are knitted together to form a selvage. Filling loops thus locked are from alternate sheds—odd numbers at one side, and even at the other.

Two filling needles, one at each side, are carried upon magnesium arms which are pivoted on rotating cranks. An extension toward the front of each arm is connected to an oscillating magnesium link. Each crank rotates at normal weaving speed and the link is moved back and forth at one-half this speed. As a result, the left needle goes through the shed and the filling is caught at the selvage by the knitting needle on the opposite side. On the next beat, needle number two at the right goes through the next shed and the filling is caught by a needle at the left selvage. In the meantime, needle number one has made a false stroke outside the web, due to its having been moved out of weaving action by the motion of the oscillating link.

Subsequent operations repeat this action and each time the needle carrying filling goes through the shed, the corresponding knitting needle picks up a filling loop and knits it into the previously-caught loop at that side.

The selvage knitting needles are actuated by Bakelite cams in time with each corresponding needle. Each stroke of the needle is followed by a beating-up action of the rotary reed operating at one-half weaving speed to provide two beat-up strokes per revolution. Design of the reeds provides clearance for the needles as they pass through the shed.

Harness frames are light tubular steel and slide in grooved Bakelite guides. Actuation is by cams from below the frames. Two complete webs of fabric are woven simultaneously.

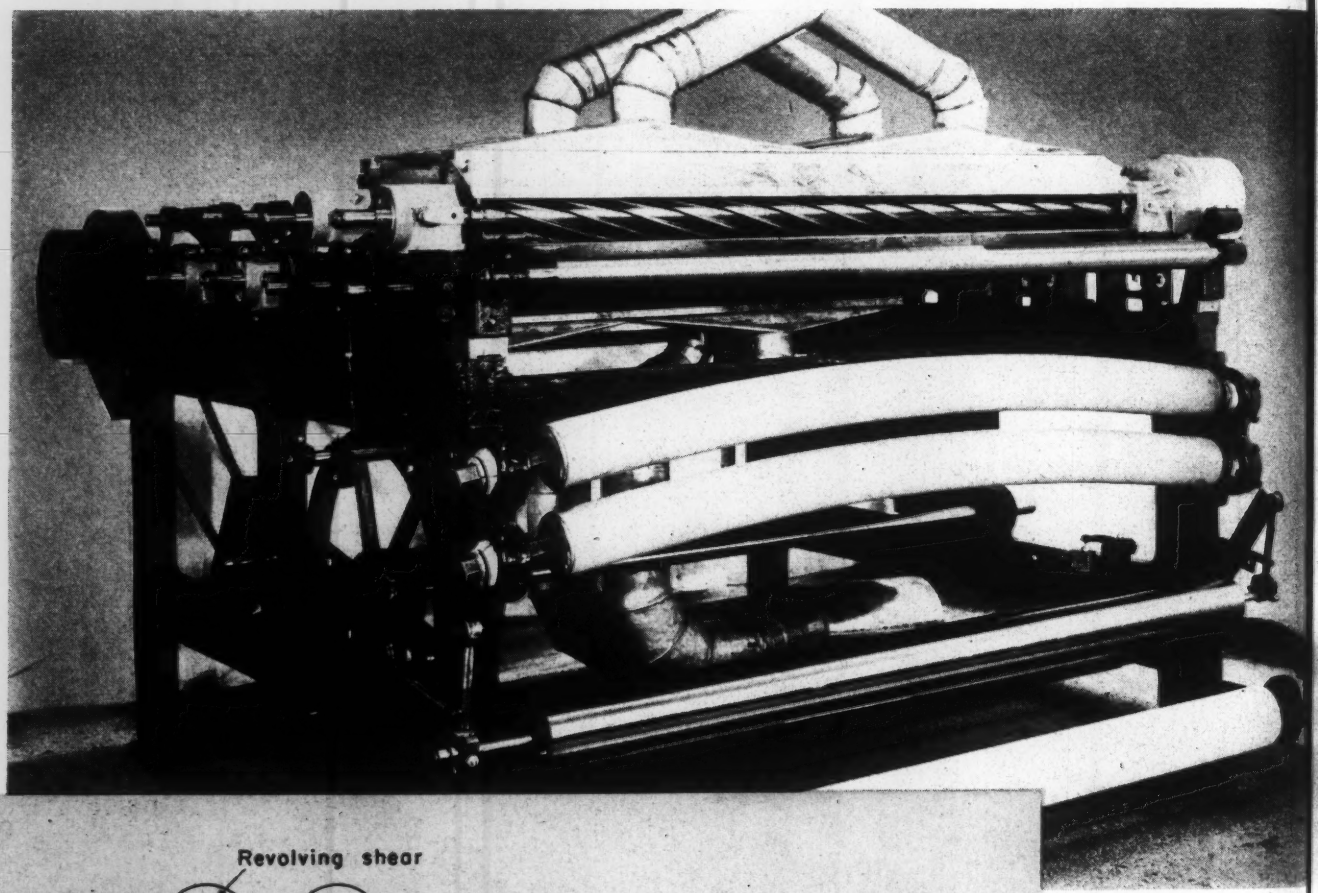


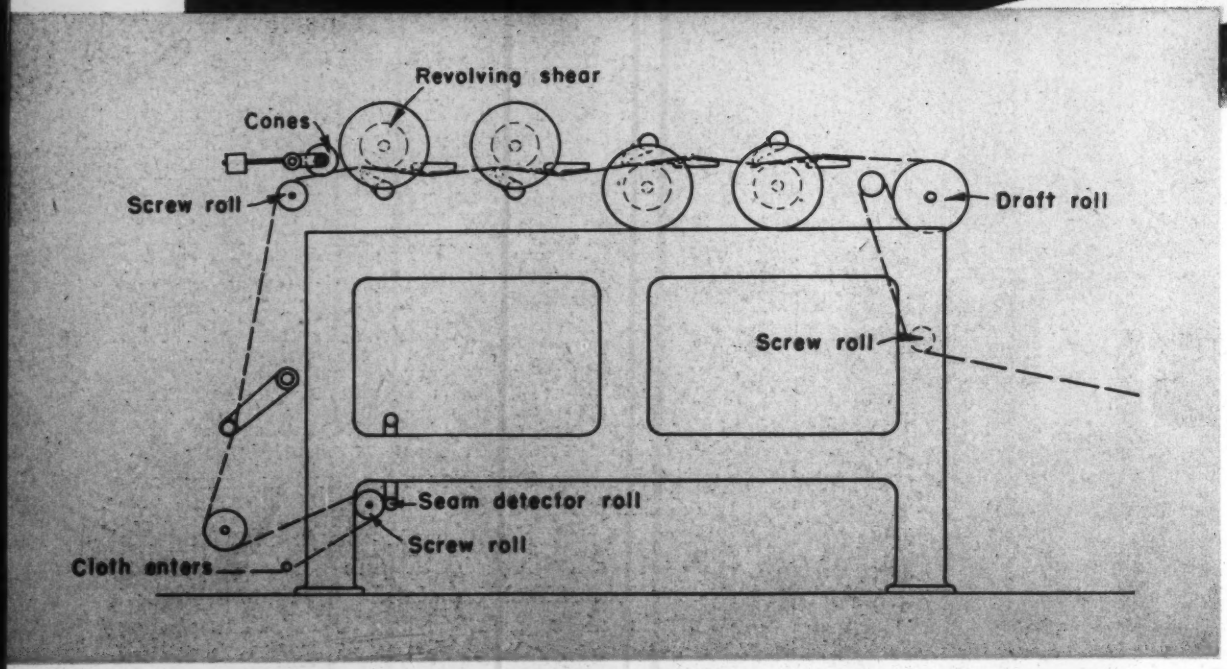
Shear Has High-Speed Reversal

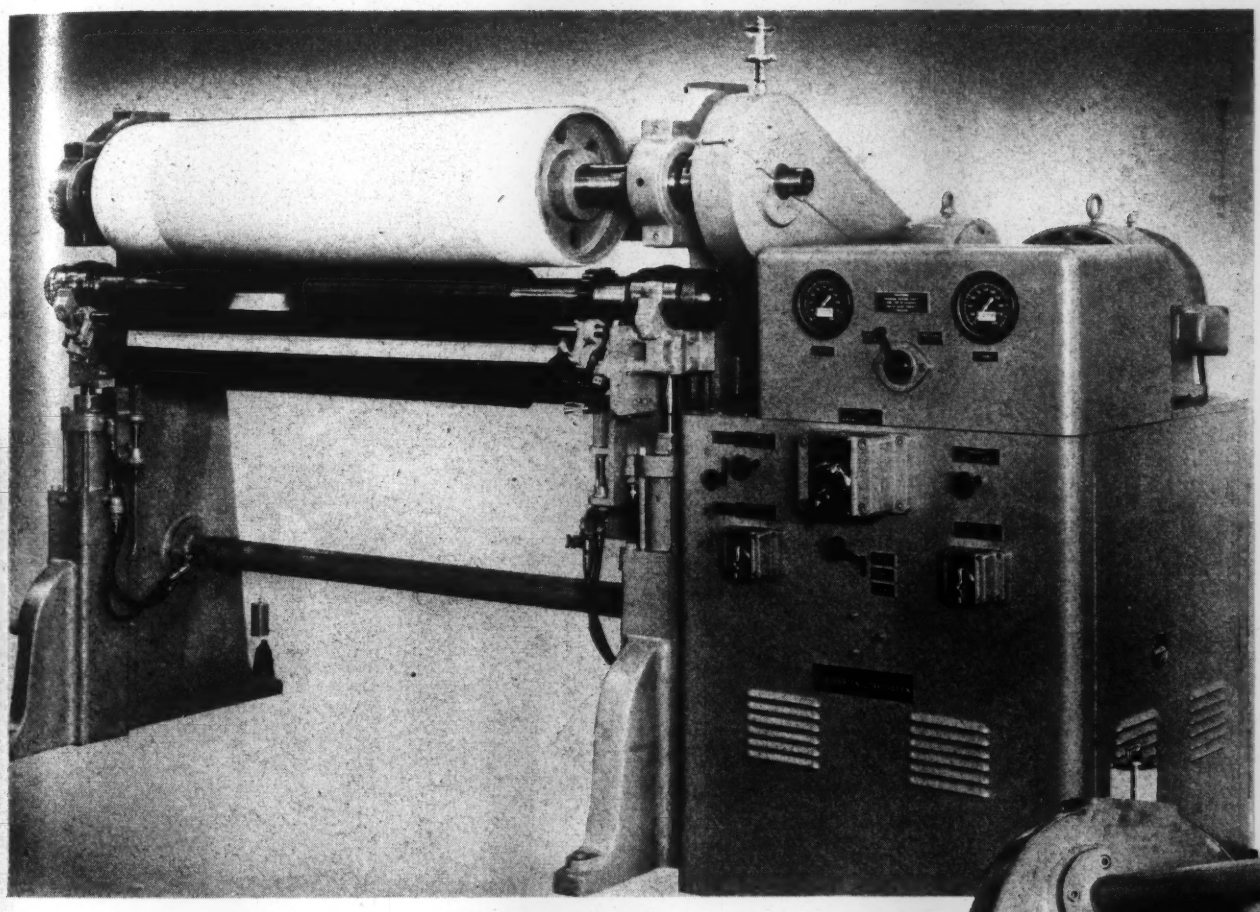
CAPABLE of the highest cloth speed of any machine built, the Curtis & Marble Machine Company's CMR Shear completely removes selvage and surface threads from cottons, rayons and silks. Individual motor drives for each revolving shear unit provide simplicity, insure constant speed and eliminate fast belts.

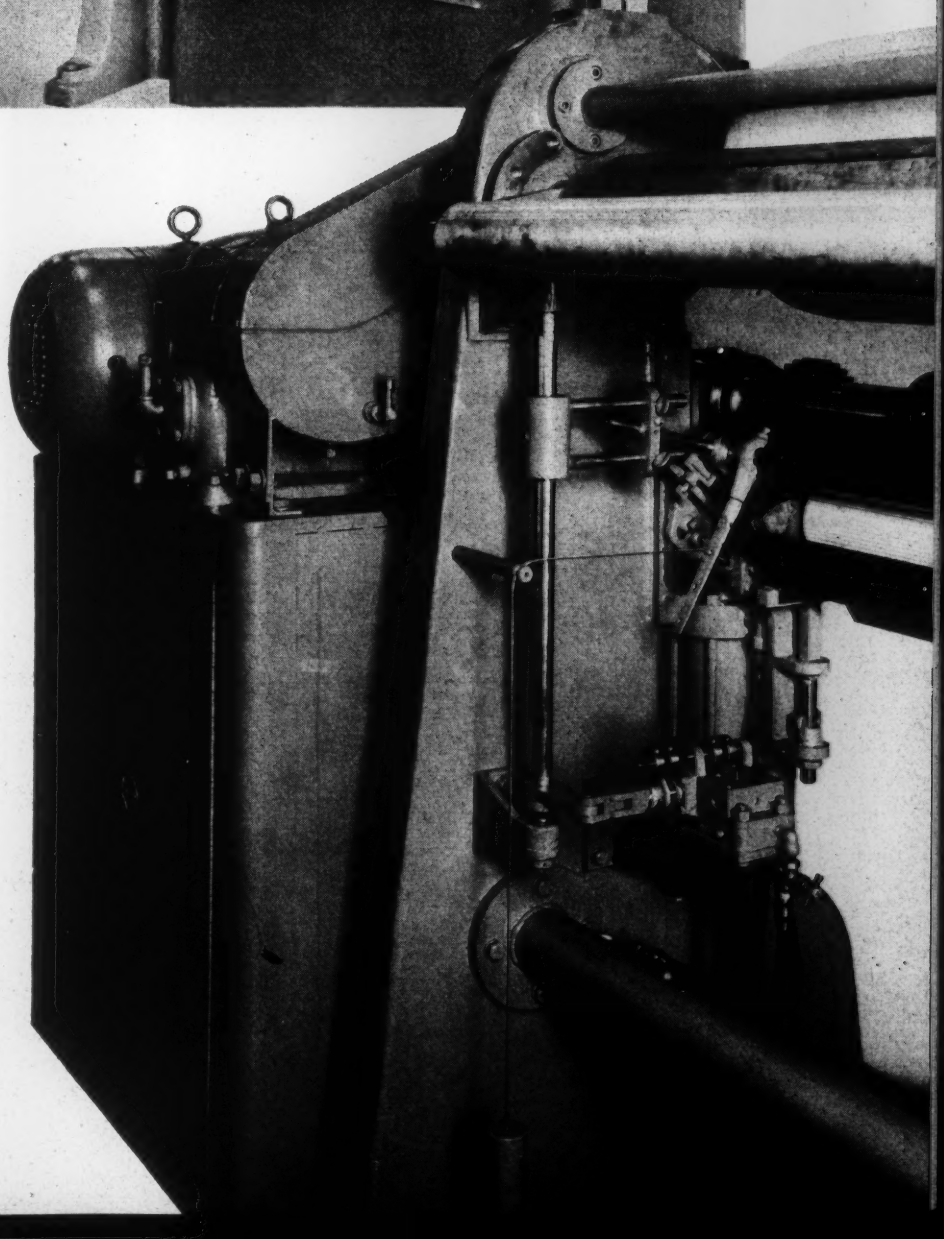
A seam-detector roll guards against passing seams or foreign substances through the cutters. When a seam is encountered, the sensitive detector roll reverses the individual drive motors until the seam passes the cutters. With the cutters revolving in reverse direction, seams and other inclusions are rejected by the blades. A pneumatic timer controls the duration of cutter reversal. Cutters reverse and resume cutting at a speed which permits less unsheared cloth operating at 90 yards per minute than was possible previously at much lower speeds.

Consisting of two curved rubber rolls and a polished metal swing roll, The Mount Hope Selvage Eliminator at the entering end of the machine eliminates wrinkles and slack selvages.





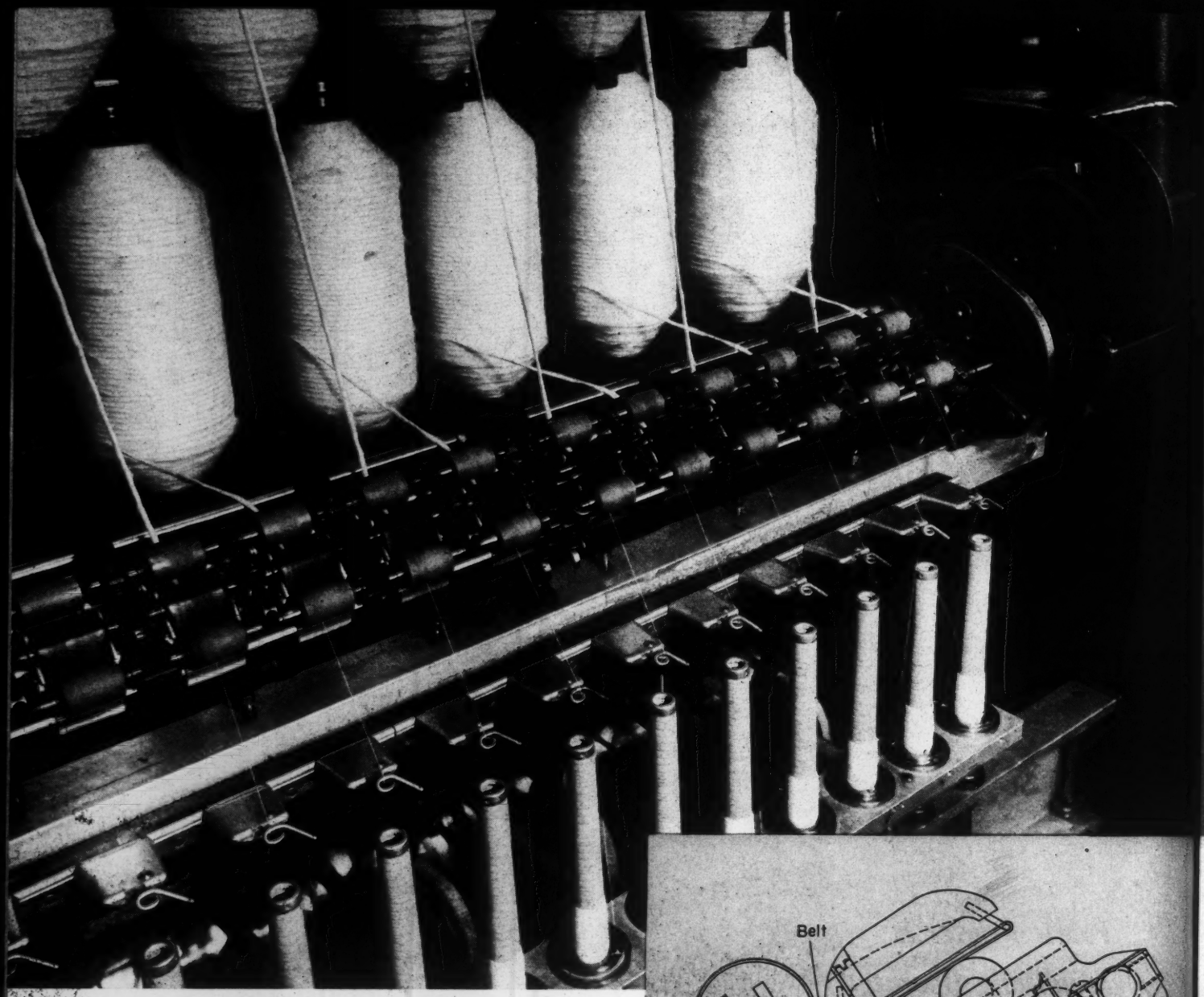


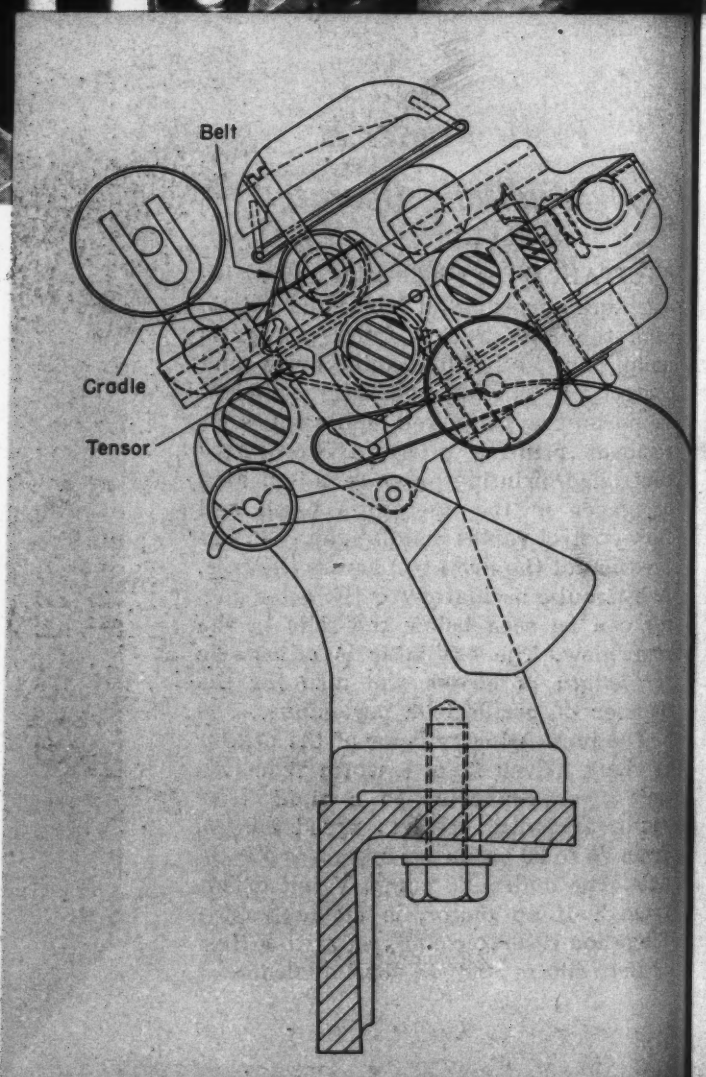


Fabric Printer is Hydraulically Operated

SUITABLE for single-color rotary intaglio printing on fabric and plastic film, the Rice Barton Corp. printer is unique in its all-hydraulic drive and control. A pair of hydraulic cylinders supports the print roll and applies or removes printing pressure. Accurately controlled, printing pressure is indicated on gages in the operator's panel and flow-control valves maintain an even impression of the print roll across the face. A hydraulic oscillator for the color doctor can be seen below the rolls in the rear view. The oscillator is adjustable for length of stroke and also for the number of oscillations per minute.

The impression cylinder of the printer is chain driven from a worm reduction unit direct-connected to a fluid drive motor. Smooth, stepless speed control from 20 to 80 yards per minute is obtainable. The hydraulic pump, V-belt driven from a 10-hp motor, is mounted on a 30-gallon reservoir equipped with a Ross cooler, filters and oil level indicator.

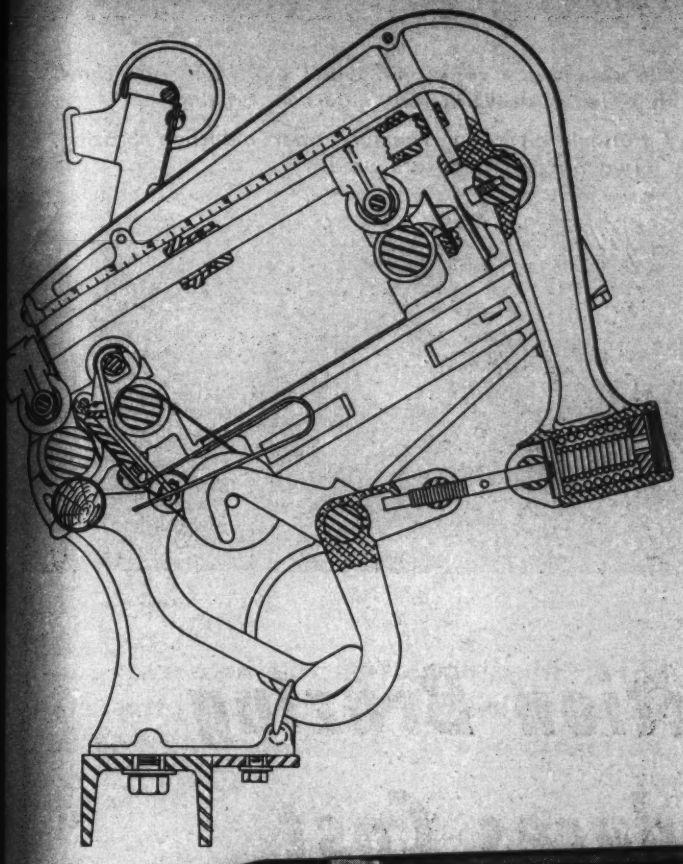




Super High-Draft System Has Belt Feed

THIS machine is based on the original Spanish Casablancas high-draft system for spinning yarn, which consists essentially of two endless belts between which the roving is held and carried forward. Designed and built by H & B American Machine Company, the machine employs cradles to guide the belts and carry a tensor arrangement which holds the belts from the inside.

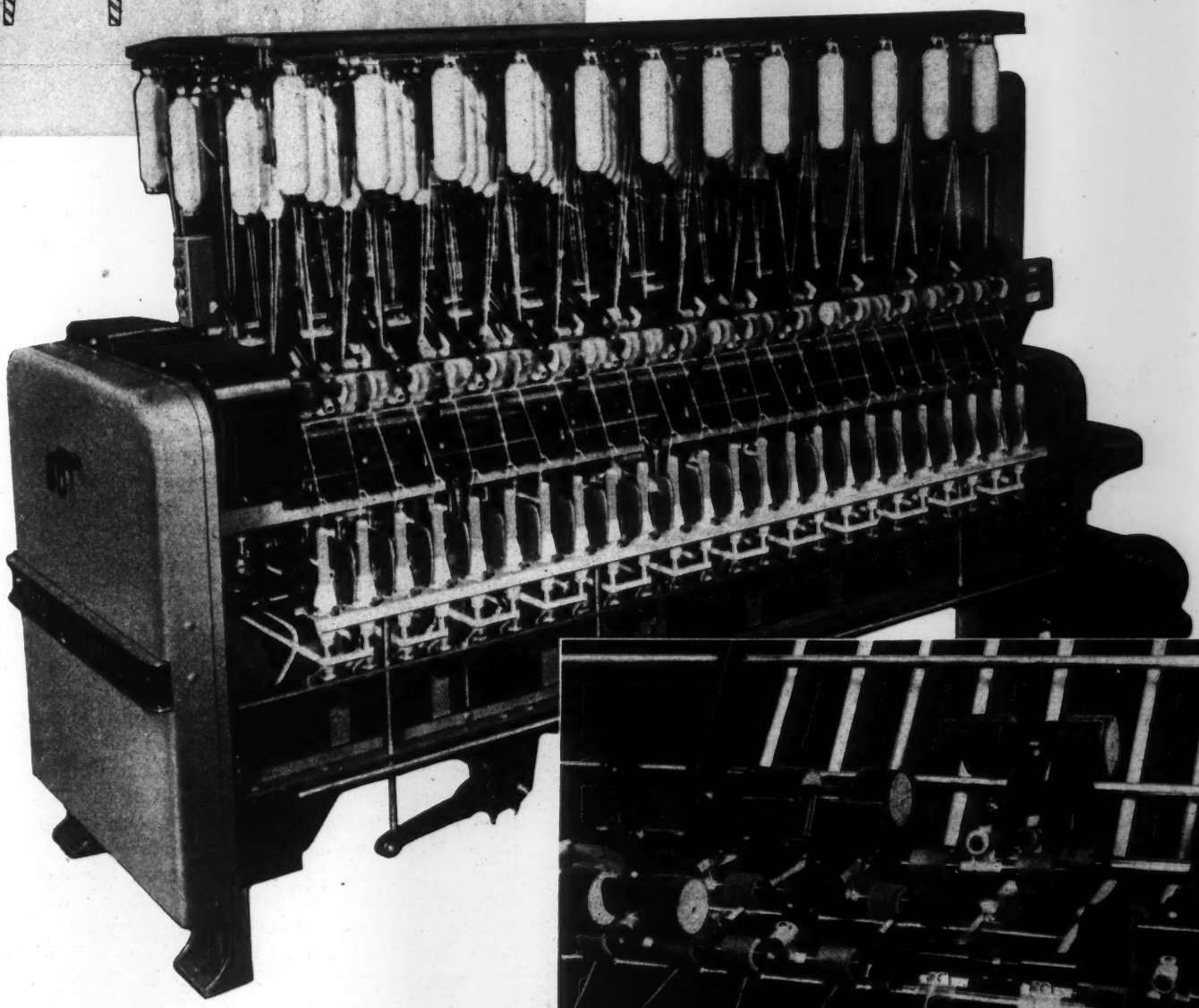
Heart of the system is this tensor unit, a two-armed part which is held against the cradle by the belts. The cradle rests on the middle drive roll and standardizes the distance between the front rollers and the delivery nip of the belts. Roll stands contain adjustable slides to permit accommodation of changes in staple length.

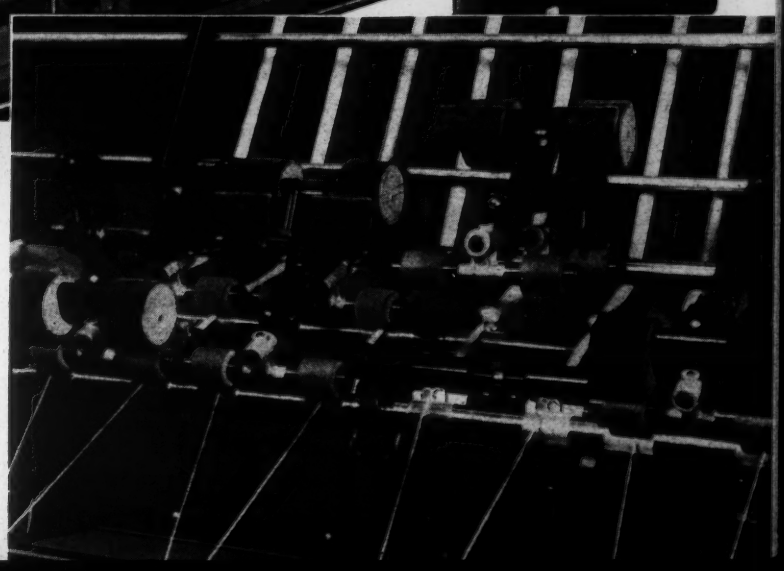


High Flexibility In Drafting Assembly

NEW drafting assembly for Saco-Lowell spinning frames features a wide range of adjustment for the production of the finest to the coarsest worsteds. Roll stands are die-cast construction. Back roll, traverse bar and roving guide for each stand are adjustable and the exact positioning of the rolls is indicated by a built-in gage on the overarm or weight horn. The weight horn is built in the form of a bell crank mounted on a pivot pin in the roll stand. Lower rear section of the bell crank contains a calibrated coil spring to pressurize the top roll at from 40 to 200 pounds.

Front, middle and back bottom rolls are case-hardened steel with special fluting. Rolls are mounted in prelubricated sealed antifriction bearings for long life and low maintenance.





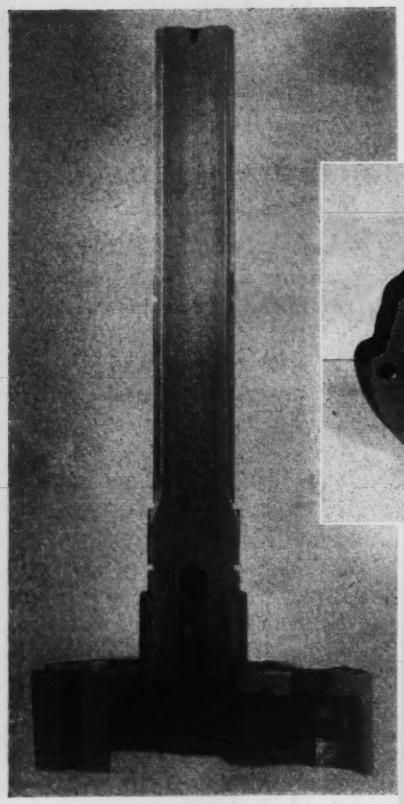
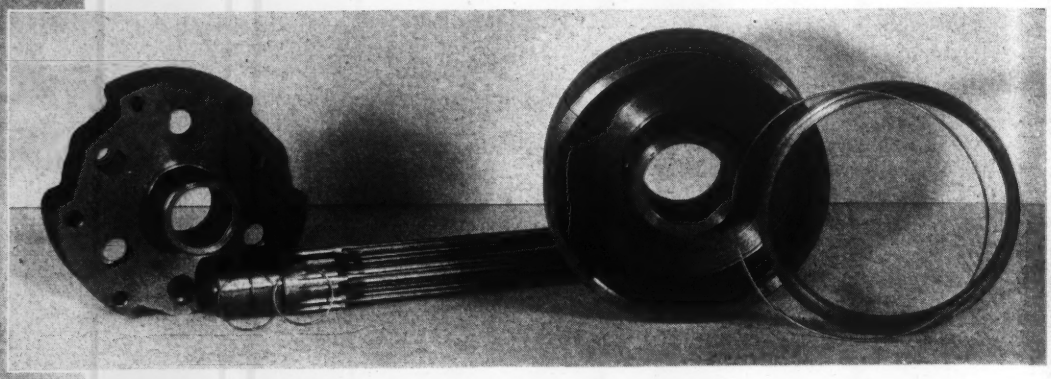


Fig. 1—Below—Ultramatic transmission cage and output shaft, left, and clutch housing with cylinder sleeve before induction brazing

Fig. 2—Left—Planetary transmission cage assembly after induction brazing. Two brazing rings are used



Induction Brazing Reduces Cost

By R. E. VanDeventer
Chief Metallurgist

and

G. S. Bidigare
Plant Metallurgist

Packard Motor Car Co.
Detroit, Mich.

CAREFUL examination of new designs is essential to be sure that the most economical materials and manufacturing methods are selected. While this is obvious, a point often missed is that a "second look" frequently discloses that slight design changes, which have no harmful effect on function, may permit the use of other materials or processes. Such changes at this stage are more attractive than they would be later after expensive tooling is established for volume production. Only by studying all practical alternates prior to production release can the engineer be sure he has done his job from the standpoint of economy.

An example of where such study paid good dividends is the planetary cage and output shaft assembly for the Packard Ultramatic transmission, shown in *Fig.* 1. As originally designed, these parts would have been made from two forgings. Metallurgical review showed that a slight design change permitted taking advantage of induction silver brazing, making it possible to use instead two pearlitic malleable castings and a steel shaft. Compared to the original construction this made a saving of $74,325.00 in the equipment and tooling cost for production, a saving of $1.74 in the cost of the parts for each unit, and permitted simplified manufacturing.

A decision to change from established practice on parts of such vital importance must be made with caution. This driveshaft transmits the entire motor torque multiplied by the transmission ratio. For cars with the eight-cylinder engines (160 hp) this amounts to a maximum of 1280 ft-lb. To determine whether ample joint strength could be obtained with a brazed construction, samples were made to the tolerances proposed and twisted in a torsion testing machine. Loads over 2600 ft-lb did not affect the brazed joint, but were well over the yield point of the steel shaft.

Cost comparison for the two methods was based on both capital expenditures and piece cost for a production rate of 45 units per hour. For the capital costs, forging dies were estimated at $14,325.00 more than pattern costs for the comparable castings. Machine tool equipment was estimated at $60,000.00 more to handle the forgings than for the castings and separate shaft. For actual piece cost, the forgings as delivered to the machine shop were $0.27 per unit more than the castings and steel for the shaft. This was supplemented by labor saving in machining to

(*Concluded on Page* 202)

This article is based on a prize-winning paper submitted in a recent Ohio Crankshaft Co. "Economy in Production" contest.

Intermittent Mechanisms

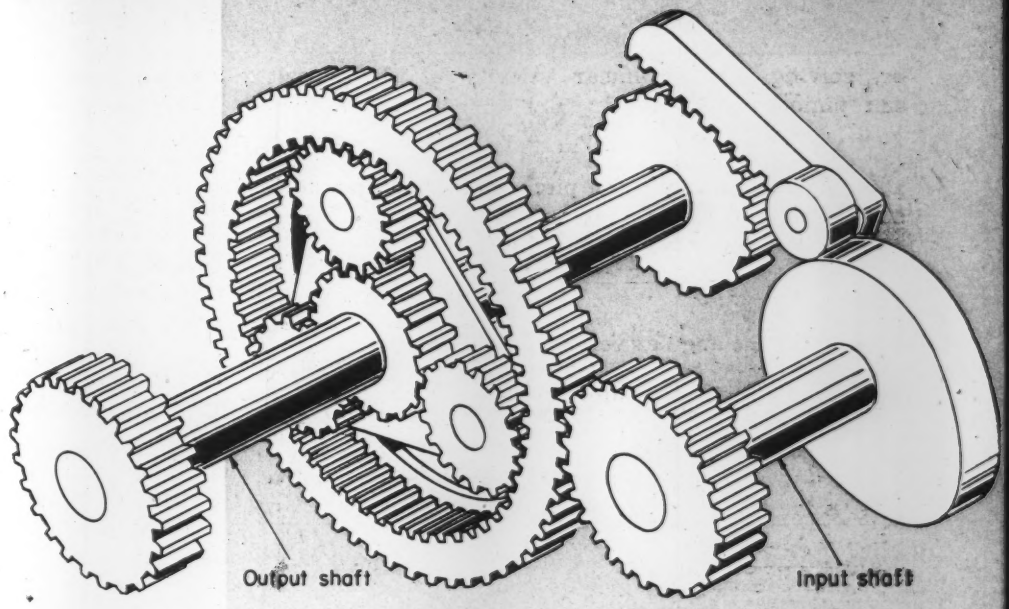


Fig. 1—Internal planetary gear system with rack-and-cam control mechanism to give intermittent motion of the output shaft

. . . provide rotary motion in both directions, with or without intermediate dwell, and continuous advance in one direction

Part 1—Planetary System

By Guy J. Talbourdet
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IN THE design of automatic machinery, the need sometimes arises for an output shaft rotating in both directions, with a continuous advance in one direction, with or without a dwell period. It has been shown (MACHINE DESIGN, Nov., 1948) that an appreciable dwell period of the output shaft can be obtained when the oscillatory member of a planetary gear system, or the reciprocating member of a screw and gear combination, is actuated by a cam. The output shaft also can be made to rotate in both directions, with or without a dwell, during a given angular displacement of a uniformly rotating input shaft.

This article presents an analysis to determine the motion of the output shaft in both directions and the characteristics of the cam actuating the oscillatory member of a planetary gear system. A subsequent article will deal in similar fashion with a screw and gear mechanism.

As shown in *Figs.* 1 and 2, the mechanism consists of a driveshaft *A*, gear *B*, and cam *C*. Gear *B* meshes with gear *D* which is integral with internal gear S_2 of a planetary gear unit. Cam *C*, through its radial follower *I*, actuates rack *E* which is in mesh with gear *F* fastened to cage *G*. Cage *G* carries planet pinions *P* which are free to rotate on pins *H* mounted on *G*. Planet pinions *P* also engage with internal sun gear S_2 and output pinion S_1.

The complete mechanism is thus a simple internal planetary system in which internal gear S_2 is the driving member rotating at a uniform velocity, while the arm or cage carrying the planet pinions is controlled by the motion of a cam follower.

To meet the three distinct conditions of motion of the output shaft—clockwise rotation, counterclockwise rotation and dwell—the analysis will deal separately with each in the order given, although this order can be changed to meet any specifications. Then the results of these three distinct motions can be added to obtain the motion of the output shaft and of the cage. The analysis assumes the input shaft to rotate clockwise.

CLOCKWISE ROTATION OF OUTPUT SHAFT: Zero acceleration and zero deceleration at the start and at the end of the motion of the output shaft will be obtained with a motion defined by the following equations (see Nomenclature):

$$\theta_{s1} = k_1 \ (K_1\theta - \sin K_1\theta) \quad \ldots\ldots (1)$$

$$\omega_{s1} = k_1 K_1 \ \omega \ (1 - \cos K_1\theta) \quad \ldots\ldots (2)$$

$$\alpha_{s1} = k_1 K_1^2 \omega^2 \sin K_1\theta \quad \ldots\ldots (3)$$

where θ varies from 0 to θ_1.

Motion of Cage: From *Fig.* 3, which shows the linear velocities at key points in the planetary mechanism,

$$-V_{s2} + V_{s1} = 2\,[-V_{s2} - (-V_{A1})]$$

or, solving for the linear velocity of the output sun pinion,

$$V_{s1} = 2\,V_{A1} - V_{s2}$$

Dividing both sides by the pitch radius of the output sun pinion,

$$\omega_{s1} = \frac{2\omega_{A1}R_A - \omega_{s2}R_{s2}}{R_{s1}}$$

Solving for the angular velocity of the cage,

$$\omega_{A1} = \frac{\omega_{s1}R_{s1} + \omega_{s2}R_{s2}}{2R_A}$$

But $\omega_{s2} = -m_1\omega$, $R_{s2} = m_2R_{s1}$, and $R_A = \frac{1}{2}R_{s1}(m_2+1)$. Therefore

$$\omega_{A1} = \frac{\omega_{s1} - m_1m_2\omega}{m_2+1}$$

$$= \frac{\omega}{m_2+1}[k_1K_1(1-\cos K_1\theta) - m_1m_2] \quad \ldots\ldots (4)$$

Angular displacement of the cage is found by integration of Equation 4 with respect to time:

$$\theta_{A1} = \frac{\omega}{m_2+1}\int [k_1K_1(1-\cos K_1\omega t) - m_1m_2]\,dt$$

$$= \frac{1}{m_2+1}[k_1K_1\,\omega t - k_1\sin K_1\omega t - m_1m_2\,\omega t] + c$$

To find the constant of integration, when $t = 0$, $\omega t = 0$ and $\theta_{A1} = 0$, therefore $c = 0$. Replacing ωt by θ,

$$\theta_{A1} = \frac{1}{m_2+1}[\theta\,(k_1K_1 - m_1m_2) - k_1\sin K_1\theta] \quad \ldots\ldots (5)$$

Angular acceleration of the planet cage is found by differentiation of Equation 4:

$$\alpha_{A1} = \frac{k_1K_1^2\omega^2\sin K_1\theta}{m_2+1} \quad \ldots\ldots (6)$$

In Equations 4, 5 and 6, θ varies from 0 to θ_1. When $\theta = \theta_1$, Equation 5 becomes (because $K_1\theta_1 = 2\pi$):

$$\theta_{A1} = \frac{\theta_1}{m_2+1}(k_1K_1 - m_1m_2) \quad \ldots\ldots (7)$$

COUNTERCLOCKWISE ROTATION OF OUTPUT SHAFT: Equations of motion of the output shaft for counterclockwise motion are similar to Equations 1, 2 and 3 with the signs reversed:

$$\theta_{s2} = -k_2\,(K_2\theta - \sin K_2\theta) \quad \ldots\ldots (8)$$

$$\omega_{s2} = -k_2K_2\omega\,(1-\cos K_2\theta) \quad \ldots\ldots (9)$$

$$\alpha_{s2} = -k_2K_2^2\omega^2\sin K_2\theta \quad \ldots\ldots (10)$$

where θ varies from 0 to θ_2.

Motion of Cage: From *Fig.* 4,

$$-V_{s2} - (-V_{s1}) = 2\,[-V_{A2} - (-V_{s1})]$$

or

$$V_{s1} = 2V_{A2} - V_{s2}$$

Following the same procedure as was employed in developing Equations 4, 5, 6 and 7, the equation of motion of the cage can be derived, with these results:

$$\omega_{A2} = \frac{\omega_{s1} - m_1m_2\omega}{m_2+1}$$

$$= -\frac{\omega}{m_2+1}[k_2K_2(1-\cos K_2\theta) + m_1m_2] \quad \ldots (11)$$

$$\theta_{A2} = -\frac{1}{m_2+1}[\theta\,(k_2K_2 + m_1m_2) - k_2\sin K_2\theta] \quad \ldots (12)$$

$$\alpha_{A2} = -\frac{k_2K_2^2\omega^2\sin K_2\theta}{m_2+1} \quad \ldots\ldots (13)$$

where θ varies from 0 to θ_2. When $\theta = \theta_2$, Equation 12 becomes

$$\theta_{A2} = -\frac{\theta_2}{m_2+1}(k_2K_2 + m_1m_2) \quad \ldots\ldots (14)$$

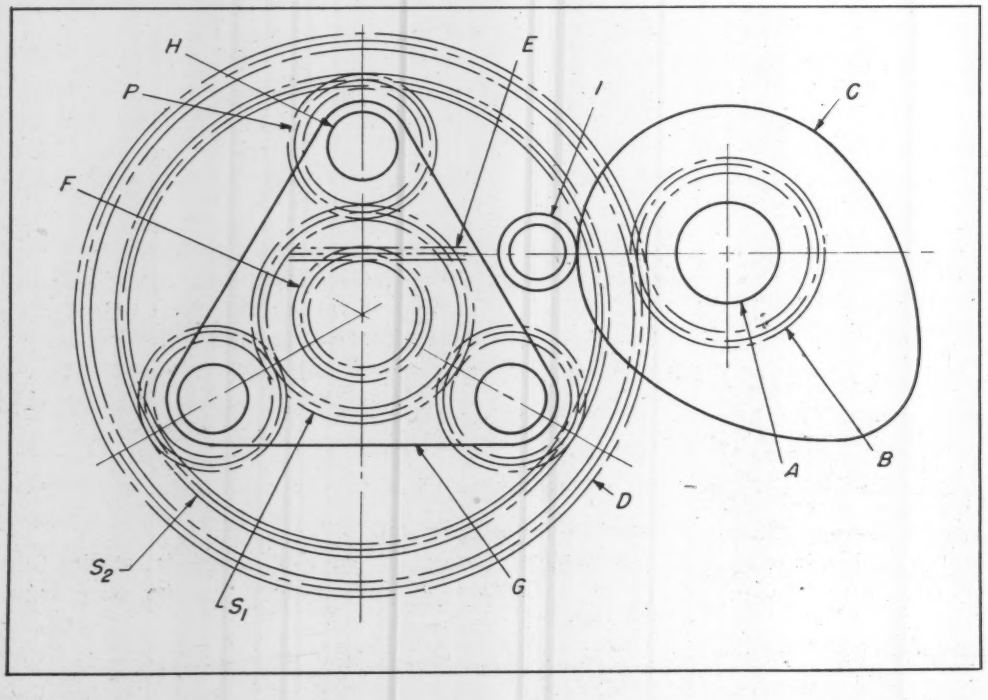


Fig. 2—End view of mechanism illustrated in Fig. 1 showing nomenclature

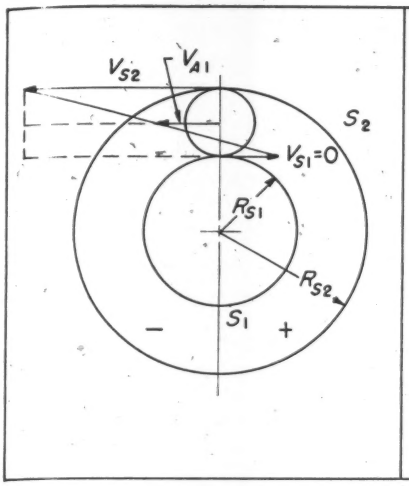


Fig. 3—Linear velocities in planetary gear system for counterclockwise rotation of internal gear S_2 and clockwise rotation of output sun gear S_1

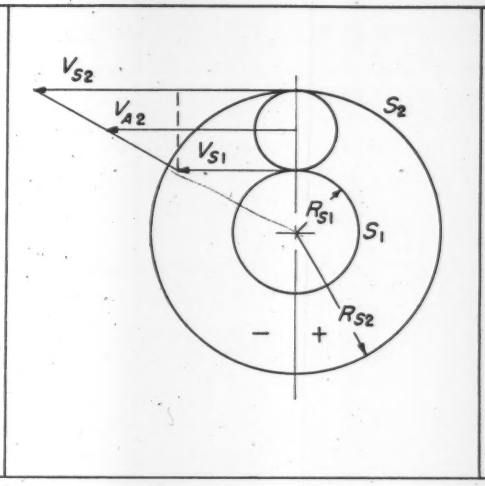


Fig. 4—Linear velocities in planetary gear system for counterclockwise rotation of both internal gear S_2 and output sun gear S_1

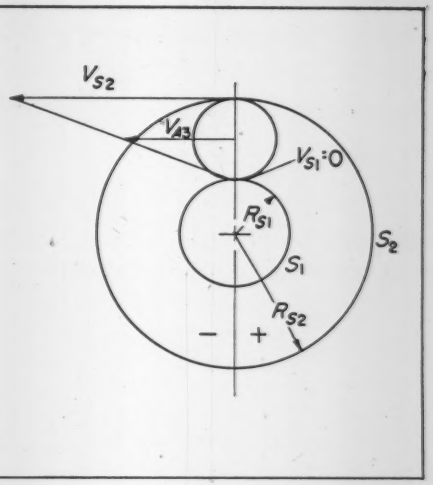


Fig. 5—Linear velocities in planetary gear system for zero speed of the output sun gear S_1

OUTPUT SHAFT STATIONARY: Here $\theta_{s3} = 0$, $\omega_{s3} = 0$ and $\alpha_{s3} = 0$.

Motion of Cage: From *Fig.* 5, $\omega_{s1} = 0$ and $V_{s1} = 0$, therefore $-V_{s2} = -2V_{A3}$ and $V_{A3} = V_{s2}/2$. Dividing by the center distance R_A.

$$\omega_{A3} = \frac{\omega_{s2} R_{s2}}{2R_A}$$

But $\omega_{s2} = -m_1\omega$, $R_{s2} = m_2 R_{s1}$, and $R_A = \frac{1}{2}R_{s1}$ times (m_2+1), therefore substitution gives

$$\omega_{A3} = -\frac{m_1 m_2 R_{s1}\omega}{(m_2+1)\,R_{s1}} = -\frac{m_1 m_2 \omega}{m_2+1} \quad \ldots\ldots\ldots (15)$$

Integrating to obtain the displacement:

$$\theta_{A3} = \int \omega_{A3}\, dt = -\frac{m_1 m_2}{m_2+1}\int \omega dt = -\frac{m_1 m_2}{m_2+1}\,\omega t + c$$

When $t = 0$, $\theta_{A3} = 0$, therefore $c = 0$, and

Nomenclature

θ = Angular displacement of uniformly rotating member

ω = Angular velocity of uniformly rotating member, radians per second

R_{s1} = Pitch radius of output sun pinion, inches

R_{s2} = Pitch radius of internal sun gear, inches

R_p = Pitch radius of planet pinion, inches

R_A = Distance between centers of sun and planet pinions, inches

R_F = Pitch radius of cage gear, inches

V_{s1} = Pitch-line velocity of output sun pinion, inches per second

V_{s2} = Pitch-line velocity of internal sun gear, inches per second

V_A = Linear velocity of center of planet pinions, inches per second

ω_{s2} = Angular velocity of internal sun gear, radians per second

$\theta_{s1}, \omega_{s1}, \alpha_{s1}$ = Clockwise angular motion of output shaft

$\theta_{s2}, \omega_{s2}, \alpha_{s2}$ = Counterclockwise angular motion of output shaft

$\theta_{A1}, \omega_{A1}, \alpha_{A1}$ = Angular motion of cage during clockwise angular motion of output shaft

$\theta_{A2}, \omega_{A2}, \alpha_{A2}$ = Angular motion of cage during counterclockwise motion of output shaft

$\theta_{A3}, \omega_{A3}, \alpha_{A3}$ = Angular motion of cage during rest period of output shaft

θ_1 = Total angular displacement of uniformly rotating cam during clockwise motion of output shaft

θ_2 = Total angular displacement of uniformly rotating cam during counterclockwise motion of output shaft

θ_3 = Total angular displacement of uniformly rotating cam during rest period of output shaft

$\theta_1 + \theta_2 + \theta_3 = 2\pi$

K_1 = Ratio between a complete cam cycle and its angular displacement required to rotate output shaft clockwise a desired amount $= 2\pi/\theta_1$

K_2 = Ratio between a complete cam cycle and its angular displacement required to rotate output shaft counterclockwise a desired amount $= 2\pi/\theta_2$

k_1 = Ratio between angular displacement of output shaft rotating clockwise and a complete cam cycle $= \theta_{s1\,max}/2\pi$

k_2 = Ratio between angular displacement of output shaft rotating counterclockwise and a complete cam cycle $= \theta_{s2\,max}/2\pi$

$k_1K_1 = \theta_{s1\,max}/\theta_1$

$k_2K_2 = \theta_{s2\,max}/\theta_2$

N_B = Number of teeth in driving gear

N_D = Number of teeth in driven external gear

N_{s2} = Number of teeth in internal sun gear

N_{s1} = Number of teeth in output sun pinion

m_1 = Gear ratio between driving and external gear $= N_B/N_D$

m_2 = Gear ratio between internal sun gear and output sun pinion $= N_{s2}/N_{s1}$

$$\theta_{A3} = -\frac{m_1 m_2 \theta}{m_2 + 1} \quad \ldots\ldots (16)$$

Differentiating to obtain the acceleration:

$$\alpha_{A3} = \frac{d}{dt}\omega_{A3} = 0 \quad \ldots\ldots (17)$$

where θ_{A3} varies from 0 to θ_3. When $\theta = \theta_3$, Equation 16 becomes

$$\theta_{A3} = -\frac{m_1 m_2 \theta_3}{m_2 + 1} \quad \ldots\ldots (18)$$

GEAR RATIO RELATIONSHIPS: To obtain the desired conditions of motion of the output shaft, the position of the cage must be the same at the start and at the end of the cam cycle:

$$\theta_{A1} + \theta_{A2} + \theta_{A3} = 0 \quad \ldots\ldots (19)$$

where θ_{A1}, θ_{A2} and θ_{A3} have the values indicated in Equations 7, 14 and 18 respectively. Substituting these values in Equation 19 and simplifying,

$$m_1 m_2 = \frac{k_1 K_1 \theta_1 - k_2 K_2 \theta_2}{\theta_1 + \theta_2 + \theta_3} \quad \ldots\ldots (20)$$

But $\theta_1 + \theta_2 + \theta_3 = 2\pi$, $k_1 K_1 = \theta_{s1\,max}/\theta_1$, and $k_2 K_2 = \theta_{s2\,max}/\theta_2$ (see Nomenclature). Also, $k_1 = \theta_{s1\,max}/2\pi$ and $k_2 = \theta_{s2\,max}/2\pi$, therefore Equation 20 may be written

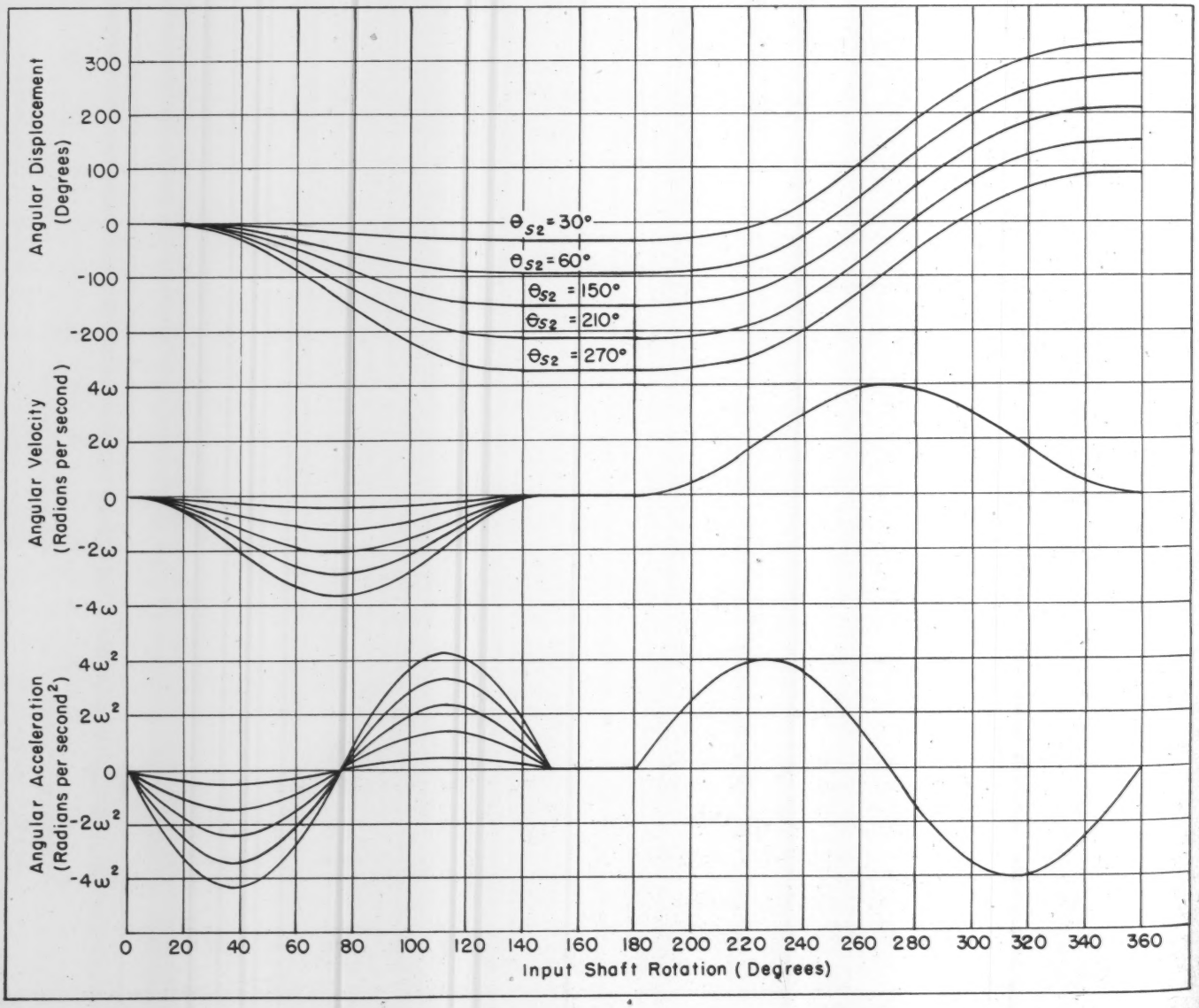
$$m_1 m_2 = \frac{\theta_{s1\,max} - \theta_{s2\,max}}{2\pi} = k_1 - k_2 \quad \ldots\ldots (21)$$

From Equation 21 it can be seen that $\theta_{s1\,max}$ and $\theta_{s2\,max}$, the clockwise and counterclockwise motions of the output shaft, cannot be equal; also that $m_1 m_2$ is not affected by any dwell period. Thus to obtain the desired motion of the output shaft, $m_1 m_2$ must satisfy Equation 21.

CAM DESIGN DATA: When gear cage F is actuated by a rack and radial cam follower the equations of motion of rack and radial cam follower are as in *Figs.* 1 and 2,

$$S_{R1} = R_F \theta_{A1} \qquad S_{R2} = R_F \theta_{A2} \qquad S_{R3} = R_F \theta_{A3}$$

Fig. 6—Angular displacement, velocity and acceleration of output shaft as a function of input shaft displacement



$$V_{R1} = R_F\omega_{A1} \qquad V_{R2} = R_F\omega_{A2} \qquad V_{R3} = R_F\omega_{A3}$$

$$a_{R1} = R_F\alpha_{A1} \qquad a_{R2} = R_F\alpha_{A2} \qquad a_{R3} = 0$$

where R_F is the radius of gear F; S_{R1}, S_{R2} and S_{R3} are, respectively, the linear displacement of the rack in inches during the clockwise, counterclockwise, and dwell period of the output shaft; V_{R1}, V_{R2} and V_{R3} are respectively the linear velocities of the rack in inches per second; a_{R1}, a_{R2} and a_{R3} are respectively the linear accelerations of the rack in inches per second per second.

When gear cage is actuated by a gear segment and a swinging cam follower, the equations of motion of gear segment and cam follower are:

$$\theta_{f1} = \frac{R_F}{R_f}\theta_{A1} \qquad \theta_{f2} = \frac{R_F}{R_f}\theta_{A2} \qquad \theta_{f3} = \frac{R_F}{R_f}\theta_{A3}$$

$$\omega_{f1} = \frac{R_F}{R_f}\omega_{A1} \qquad \omega_{f2} = \frac{R_F}{R_f}\omega_{A2} \qquad \omega_{f3} = \frac{R_F}{R_f}\omega_{A3}$$

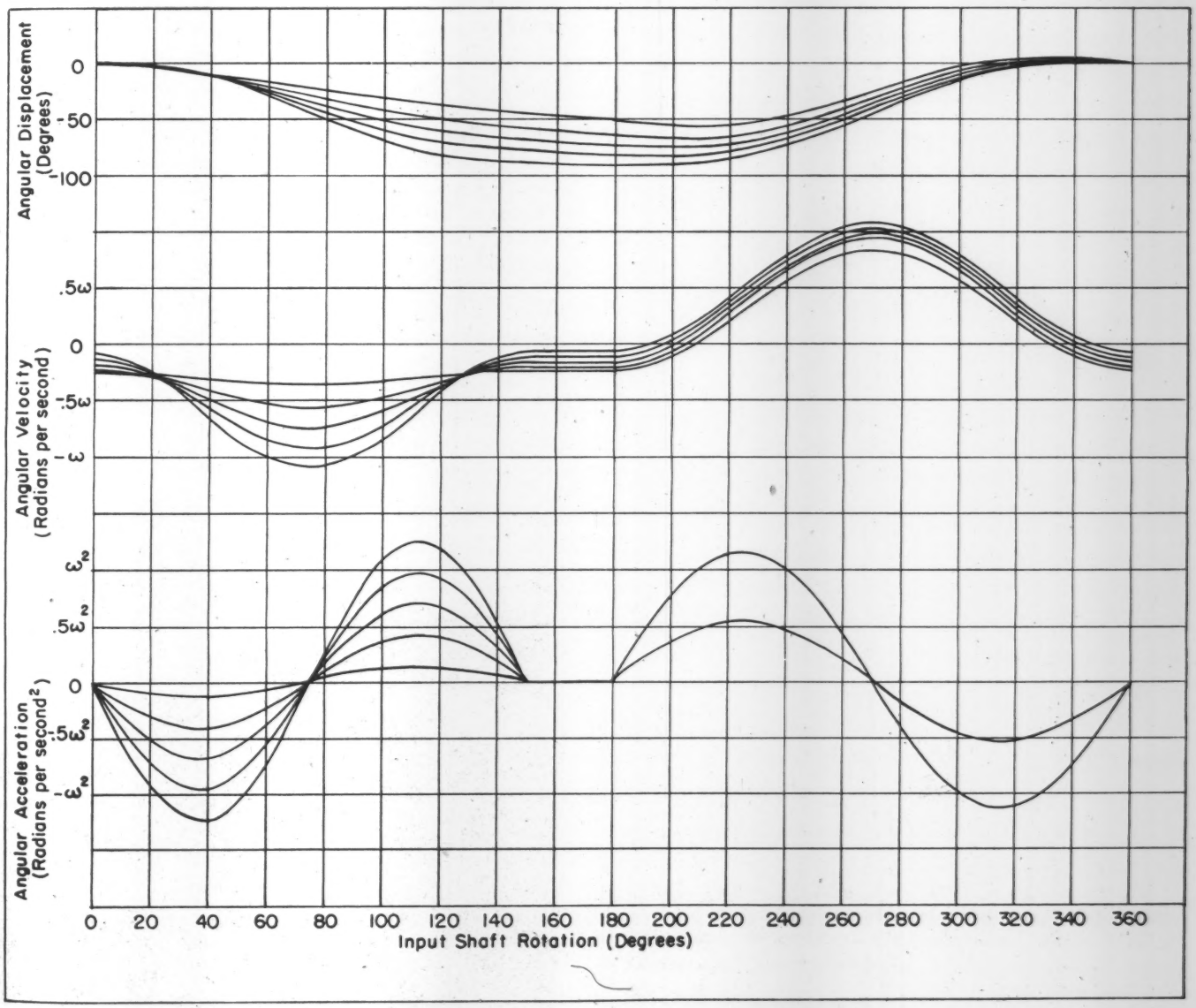
$$\alpha_{f1} = \frac{R_F}{R_f}\alpha_{A1} \qquad \alpha_{f2} = \frac{R_F}{R_f}\alpha_{A2} \qquad \alpha_{f3} = 0$$

where R_f is the pitch radius of the segment, inches; θ_{f1}, θ_{f2} and θ_{f3} are respectively, the angular displacements of the gear segment during the three phases of motion; α_{f1}, α_{f2} and α_{f3} are respectively, the angular accelerations of the gear segment, radians per second per second.

The motions of the output shaft and of the cage are illustrated in *Figs.* 6 and 7 where the angular displacement, velocity and acceleration have been plotted as a function of the angular displacement of a driveshaft rotating uniformly at the rate of one radian per second.

Fig. 6 indicates the motion of an output shaft which rotates counterclockwise during 150 degrees rotation of the input shaft, then remains stationary during 30 degrees rotation of the input shaft, and finally rotates 360 degrees clockwise during the remaining 180 degrees rotation of the input shaft. The five sets of curves are for output shaft counterclockwise rotation of 30, 90, 150, 210 and 270 degrees, respectively. *Fig.* 7 indicates the motion of the cage required to obtain the desired motions of the output

Fig. 7—Motion of planet cage corresponding to output shaft motion shown in Fig. 6



shaft under the foregoing conditions.

EXAMPLE: To illustrate the application of the equations just derived, the calculations will be worked out for the conditions shown in *Fig.* 6 and described in the preceding paragraph, for maximum counterclockwise rotation of the output shaft, θ_{s2}, equal to 90 degrees. The conditions are:

$\theta_1 = 180$ degrees $\quad \theta_3 = 90$ degrees $\quad \theta_2 = 150$ degrees

$\theta_{s1\ max} = 360$ degrees $\quad \theta_{s2} = 90$ degrees

From the Nomenclature,

$$K_1 = 2\pi/\theta_1 = 360/180 = 2$$

$$k_1 = \theta_{s1\ max}/2\pi = 360/360 = 1$$

$$K_2 = 2\pi/\theta_2 = 360/150 = 2.4$$

$$k_2 = \theta_{s2\ max}/2\pi = 90/360 = 0.25$$

From Equation 21, $m_1 m_2 = k_1 - k_2 = 1 - 0.25 = 0.75$. Letting $m_2 = 2.5$, then $m_1 = 0.3$. If $N_{s1} = 20$ teeth, $N_{s2} = 2.5 \times 20 = 50$ teeth; and if $N_B = 21$ teeth, $N_D = 21/0.3 = 70$ teeth.

Motion of the output shaft starts with the counterclockwise rotation, then the dwell period, and finally the clockwise rotation, *Fig.* 6.

For input shaft motion from 0 to 150 degrees, the output shaft motion is given by

$\theta_{s2} = -0.25\ (2.4\theta - 57.29564 \sin 2.4\theta)$ . . . . . (From Equation 8)

$\omega_{s2} = -0.6\omega\ (1 - \cos 2.4\theta)$ . . . . . (From Equation 9)

$\alpha_{s2} = -1.44\omega^2 \sin 2.4\theta$ . . . . . (From Equation 10)

where θ varies from 0 to 150 degrees.

For input shaft motion from 150 to 180 degrees the output shaft is stationary. For input shaft motion from 180 to 360 degrees the output shaft motion is given by

$\theta_{s1} = -90° + 1\ (2\theta - 57.29564 \sin 2\theta)$ . . . . . (From Equation 1)

$\omega_{s1} = 2\omega\ (1 - \cos 2\theta)$ . . . . . (From Equation 2)

$\alpha_{s1} = 4\omega^2 \sin 2\theta$ . . . . . (From Equation 3)

where θ varies from 0 to 180 *degrees.* Here θ is the actual input shaft rotation minus 180 degrees.

These values have been calculated and are plotted in *Fig.* 6 with input shaft as abscissa.

For the motion of the cage required to obtain the desired motion of the output shaft, the equations become, respectively:

For input shaft motion from 0 to 150 degrees

$\theta_{A2} = -0.28571\ [1.350\theta - 57.29564 \times 0.250 \sin 2.4\theta]$ . . . . . (From Equation 12)

$\omega_{A2} = -0.28571\omega\ [0.6\ (1 - \cos 2.4\theta) + 0.750]$ . . . . . (From Equation 11)

$\alpha_{A2} = -0.41142\omega^2 \sin 2.4\theta$ . . . . . (From Equation 13)

where θ varies from 0 to 150 *degrees.*

For input shaft motion from 150 to 180 degrees

$\theta_{A3} = -\theta_{A2\ max} - .21428\theta = -57.85628 - 0.21428\theta$ . . . . . (From Equation 16)

$\omega_{A3} = -0.21428\omega$ . . . . . (From Equation 15)

$\alpha_{A3} = 0$ . . . . . (From Equation 17)

where θ varies from 0 to 30 degrees.

For input shaft motion from 180 to 360 degrees

$\theta_{A1} = \theta_{A2\ max} + \theta_{A3\ max} + 0.28571\ (1.25\theta - 57.29564 \sin 2\theta)$

$= -64.28470 + 0.28571\ (1.25\theta - 57.29564 \sin 2\theta)$ . . . . . (From Equation 5)

$\omega_{A1} = 0.28571\omega\ 2(1 - \cos 2\theta) - .750$ (From Equation 4)

$\alpha_{A1} = 1.14285\omega^2 \sin 2\theta$ . . . . . (From Equation 6)

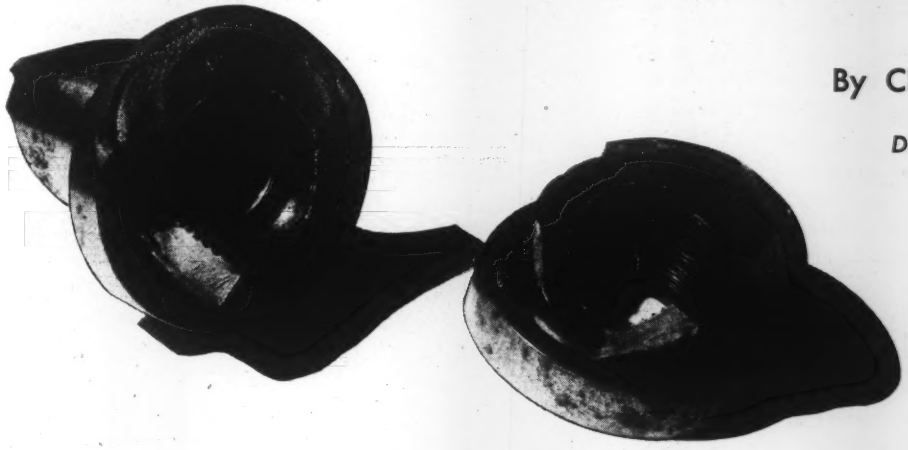
where θ varies from 0 to 180 *degrees.*

These values have been calculated and are plotted in *Fig.* 7 with the motion of input shaft as abscissa. Knowing the angular displacement of the cage, the radius vector and its co-ordinates required for the manufacture of the cam leader can be easily determined.

In the next, and concluding article similar analysis will be presented covering a screw and gear mechanism employing a cam control.

Simple Super-Speed Camera

FILM speeds of 10 to 120 feet per second are obtained with a high-speed drum camera developed at the Naval Ordnance Laboratory. Of low-cost, simple construction and convenient in operation, the camera is designed to utilize the periscope, lens and shutter of the DuMont-Fairchild equipment. A lightweight Lucite drum carries a 16-inch length of 35-mm film in a groove on the inner surface of the drum. Centrifugal force holds the film snugly against the transparent rim and exposure is made through the Lucite. The drum is driven at 400 to 4000 rpm by a Heller adjustable-speed motor flange-mounted to the Bakelite-impregnated fabric housing. Exposure of the film for more than one revolution of the drum is avoided by use of beam unblanking and blanking circuits of the oscilloscope.



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Why Machine Parts Fail

Part 5—Bending and Tensile Fractures

IN the first three articles of this series the types and causes of failure were presented, together with the various factors which affect the origin and the propagation of cracks. The fourth article presented some basic guides to recognition of fatigue failures. The present article will show how to recognize failures resulting from bending and axial loads.

FATIGUE FAILURES IN BENDING: Fatigue failures caused by bending loads have all the characteristics described in the preceding article. The fracture face is composed of two zones: a smooth, velvety, dull *fatigue* zone, which may or may not show stop marks; and a coarse, bright, crystalline *instantaneous fracture* zone. Relative sizes, shapes and locations of these two zones are determined by the magnitude and direction of the imposed loads as well as by the presence or absence of stress concentration notches. Symbols and nomenclature used to designate fracture appearances in this and following articles are shown in *Fig.* 43.

The sketches comprising TABLE 2 indicate qualitatively the effect of method of loading, magnitude of overload, and stress concentration on the appearance of fracture. Conversely, from the appearance of fracture the type of load responsible for failure can be determined. Three principal cases are covered in TABLE 2 and the discussion which follows:

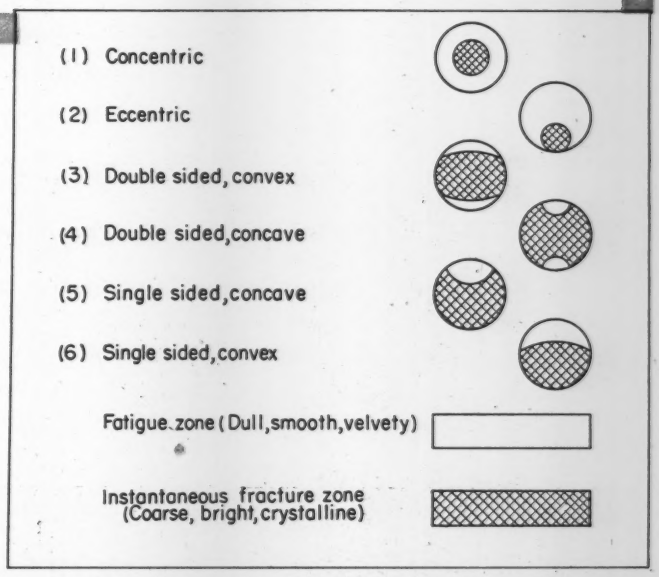


Fig. 43—Symbols and nomenclature established by Bacon are useful for the designation of fracture appearances

Case 1. One-way bending load
Case 2. Two-way bending load
Case 3. Reversed bending and rotation load.

Case 1 with no stress concentration: Maximum stress occurs at the surface or, for a round bar, at the extreme radius. Under this stress a small elliptically shaped fatigue crack starts at the most susceptible nucleus, such as a tool mark or other surface flaw. Because of the decrease in distance from the neutral axis, the stress at the edge of this crack becomes smaller. As the crack progresses inwardly,

Photo at top of page, courtesy Chicago Pneumatic Tool Co.

its radius of curvature increases, as shown by Sketches 1*a* and 1*b* in TABLE 2. The relative proportions of the smooth and ragged areas, corresponding to the fatigue and instantaneous zones, respectively, will depend upon the degree of overstress to which the member is subjected. A relatively large instantaneous zone is indicative of high overstress, Sketch 1*b*; a small instantaneous zone is the result of low overstress and often a great number of cycles prior to failure, Sketch 1*a*. Frequently a second crack starts in the compression area, probably due to tensile stresses caused by elastic forces tending to restore the part to its original shape during the unstressed portion of the fatigue cycle.

Case 1 *with mild stress concentration:* In a member having a notch, the forces around the base of the notch are abnormally high because of stress concentration. This causes the contour of the crack to flatten out, as shown in Sketches 1*c* and 1*d*, because the crack progresses around the circumference nearly as fast as it progresses inwardly. The size of the instantaneous fracture zone again is determined by the relative amount of overstressing, Sketch 1*c* showing low overstress and 1*d* high overstress.

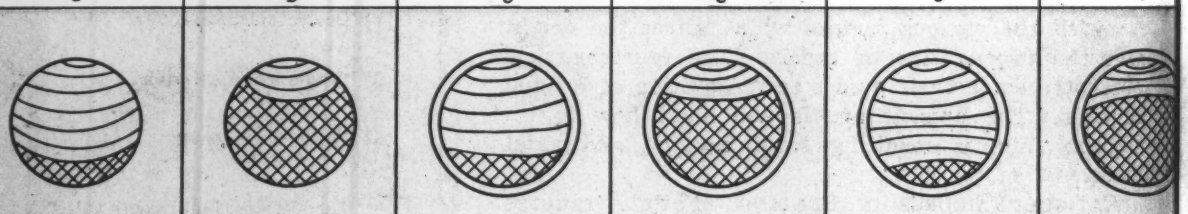
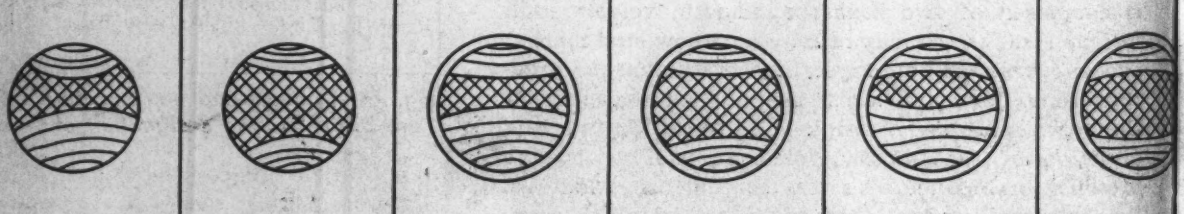
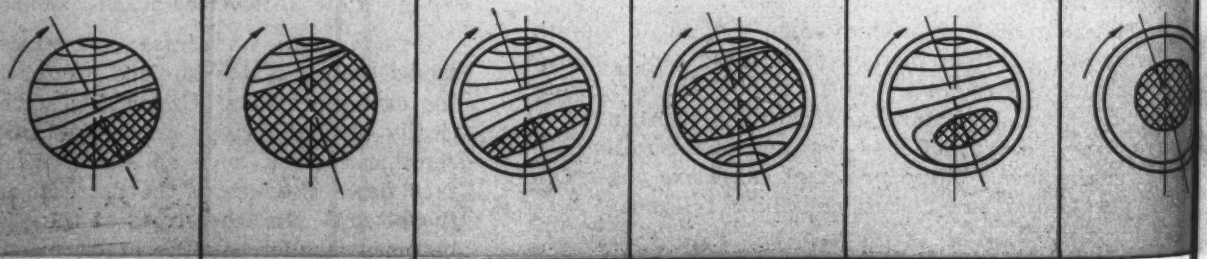
Case 1 *with high stress concentration:* If the stress concentration is sufficiently large, the curvature of the fracture zone actually changes sign and becomes concave, as shown in Sketches 1*e* and 1*f*, because the rate of crack propagation along the periphery is greater than the rate in the radial direction.

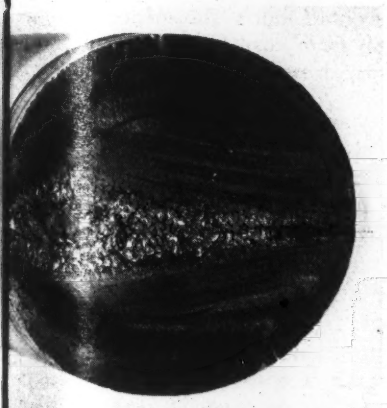
Case 2 *with no stress concentration:* For a member highly but uniformly overstressed, the cracks start almost simultaneously at the opposite extreme fibers, proceed toward the center at approximately equal speeds, and produce a symmetrical fracture, as shown in Sketch 2*b*. For a member lightly overstressed, the surface conditions and accidental influences play a much more important part. The fracture starts at a local stress concentration and progresses part way before the crack on the other side starts. This makes the unsymmetrical fracture illustrated in Sketch 2*a*. The amount of overstressing determines the size of the instantaneous fracture zone.

Case 2 *with mild stress concentration:* The presence of a mild stress concentration has the effect of flattening the curvature of the instantaneous zone due to greater growth of the crack around the periphery than in a radial direction as shown in Sketches 2*c* and 2*d*. As pointed out previously the amount of overstressing determines the size and symmetry of the instantaneous fracture zone.

Case 2 *with high stress concentration:* A high stress concentration causes the crack to propagate around the periphery at such a high rate that the curvature of the fracture zone is inverted from concave to convex, as shown in Sketches 2*e* and 2*f*. All other factors affecting fracture for the case of one-way bending previously discussed are applicable here. An actual

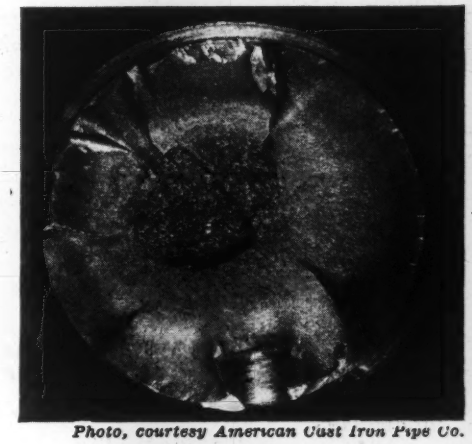
Table 2—Fracture Appearances of Fatigue Failures in Bending

Case \ Stress Condition	No Stress Concentration		Mild Stress Concentration		High Stress Concentration	
	Low Overstress *a*	High Overstress *b*	Low Overstress *c*	High Overstress *d*	Low Overstress *e*	High Overstr *f*
1 One-way bending load						
2 Two-way bending load						
3 Reversed bending and rotation load						



Photo, courtesy International Harvester Co.

Fig. 44—Fatigue failure of this pivot shaft occurred from reversed bending. Reversal of lines in fatigue zone indicates either high stress concentration in a mild steel or mild stress concentration in a hard steel



Photo, courtesy American Cast Iron Pipe Co.

Fig. 45—This rotary-bending fatigue failure resulted from high stress concentrations and high overloads, indicated by the centralized instantaneous fracture zone. Compare with Sketch 3f in Table 2

Fig. 46—"Crack slip" indicating rotary bending occurred in this fatigue failure. This change in orientation is also shown in Sketch 3e in Table 2. Completely enclosed, eccentrically located instantaneous fracture zone is evidence of high stress concentration and mild overstress

example of this type of failure is illustrated in *Fig.* 44.

Whether the fatigue crack terminates with a convex or concave curvature depends not only upon the degree of stress concentration and the degree of overstress, but also upon the relative toughness or brittleness of the material. For example, Sketch 2*c* is representative of fatigue failure for a mild steel with a moderate stress concentration, such as a circumferential round-bottom notch, but a notch of the same shape in a hardened steel would cause a fracture much more similar in appearance to Sketch 2*e* because of the heightened notch sensitivity of the material. Concavity of the fatigue crack in Sketch 2*e* is cause by accelerated crack growth around the periphery due to stress concentration. In general, concavity of the fatigue crack increases with increased stress concentration or notch sensitivity.

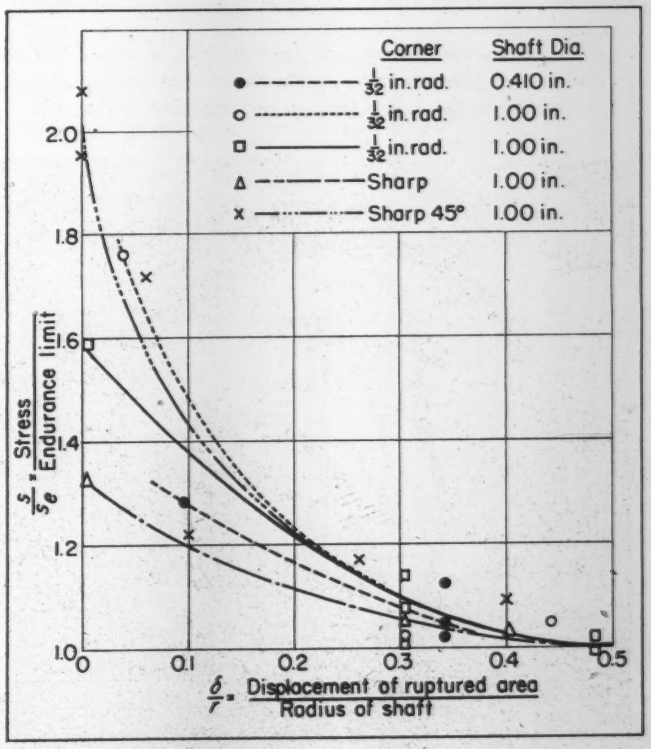
Case 3 *with no stress concentration:* The maximum stress occurs at the two extreme fibers. If, as usually is the case, the metal is weaker at one side than the other, the fracture starts at one side as a small elliptical crack. Each successive crack boundary advances radially and is of increasing radius, becoming a straight line before the center of the member is reached. Also it will be noticed that the crack "turns around" against the rotation. This phenomenon is termed *crack slip.*

With low overstress, Sketch 3*a,* the crack traverses well into the middle of the piece, or even beyond, prior to actual fracture. With high overstress the member may fail before the crack has progressed very far, giving a fracture approximately as shown in Sketch 3*b.*

Case 3 *with mild stress concentration:* With high overstress, the notch causes early crack formation and rapid crack progression around most of the periphery. Thus the instantaneous zone is centrally located on the fracture face, Sketch 3*d,* varying slightly in position with severity of the notch and ductility of the material. In contrast, slight overstressing tends to start the crack at the weakest point; the instantaneous zone is displaced from the point of crack initiation as shown in Sketch 3*c.* Only an extremely tough material under the latter condition shows no response to the stress concentration caused by a notch and shows an instantaneous area located at the periphery in a manner similar to that indicated in Sketch 3*a.*

Case 3 *with high stress concentration:* A combination of severe stress concentration and high overstress

Fig. 47—This graph by Peterson shows that the instantaneous fracture zone in reversed bending and rotation is displaced toward center of shaft as overstress is increased



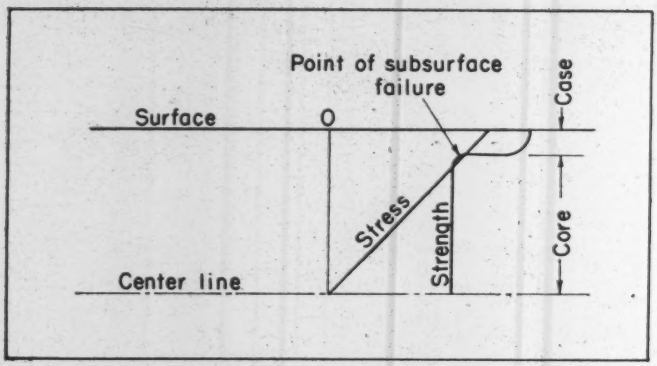


Fig. 48—Left—In surface-treated parts subsurface failure may occur at the transition from case to core where, according to their gradients, stress may exceed strength

causes fatigue cracks to start simultaneously all round the circumference. Progressing radially, the cracks leave a fairly concentric circular or elliptical instantaneous fracture well inside the fatigue area, Sketch 3*f* and *Fig.* 45. Less overstress again displaces the instantaneous zone as shown in Sketch 3*e* and *Fig.* 46. In studying a series of fractures in a low-carbon steel, Peterson[1] was able to demonstrate conclusively that the ruptured area for highly overstressed specimens tends to be centrally located and is displaced toward the edge of the specimen with less overstress, as evidenced in *Fig.* 47.

Fig. 49—Below—This fatigue failure of a nitrided part originated below the surface at the "fish eye"
Photo, courtesy Westinghouse Electric Corp.

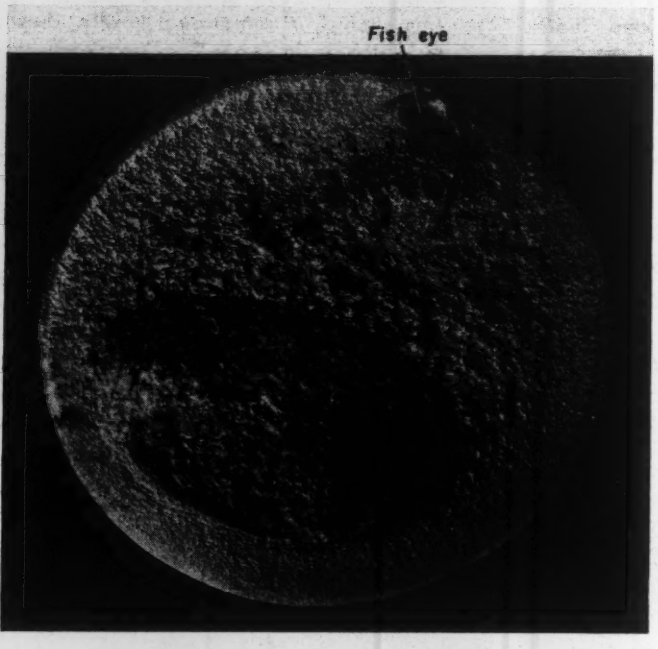


Fig. 50—Below—In this tension-fatigue failure of a press tie-rod the crack tended to spread without change in curvature because the load was approximately uniform
Photo, courtesy Briggs Manufacturing Corp.

SUBSURFACE ORIGIN OF CRACKS: Fatigue cracks can originate at points below the surface of the piece if the proper conditions exist. A fatigue crack always originates at that point in the metal where the ratio of the local stress to the endurance limit of the metal is highest. Ordinarily these points occur on the surface of the piece because the metal is comparatively uniform in strength across its section and because the stress distribution in torsion or bending results in maximum stress at the extreme fibers. Pure tension is relatively rare in machine parts.

However, there may exist at some point below the surface a crack or other metallurgical discontinuity, arising usually from fabrication processes, that causes the strength in its immediate vicinity to be considerably lower than the surface strength—especially if the piece has a smooth surface finish. The result is apt to be a fatigue crack which originates at the subsurface discontinuity and grows toward both the outside of the piece and the center. A similar situation can occur under certain conditions of nonuniform metal strength due to surface heat treatment. Here if the hardness gradient is sufficiently steep, as illustrated in *Fig.* 48, it is quite possible for the ratio of stress to strength to be highest in the region of transition from case to core. Thus, without benefit of stress concentration, a fatigue crack originates in that area, *Fig.* 49[2].

TENSILE AND COMPRESSIVE FRACTURES: Because fatigue testing in tension and compression is not very common, little information on fractures from these causes is available. However, a fatigue failure in a rotary bending test is essentially due to tension; hence, the formation of zones is approximately the same.

When a crack starts at the surface, it usually spreads fairly uniformly across the section, keeping approximately the same curvature because the stress is constant. *Fig.* 50 shows a tensile fatigue failure in the tierod of a large press.

In the next article of this series, fractures resulting from torsional loads will be analyzed.

REFERENCES

1. R. E. Peterson— "Stress Concentration Phenomena in Fatigue of Metals," *Trans. ASME*, Vol. 55, 1933.
2. R. E. Peterson and J. M. Lessells—"Effect of Surface-Strengthening on Shafts Having a Fillet or a Transverse Hole," *Proc. SESA*, Vol. II, No. 1, 1944, Page 191.

Determining Practical Forging Cost

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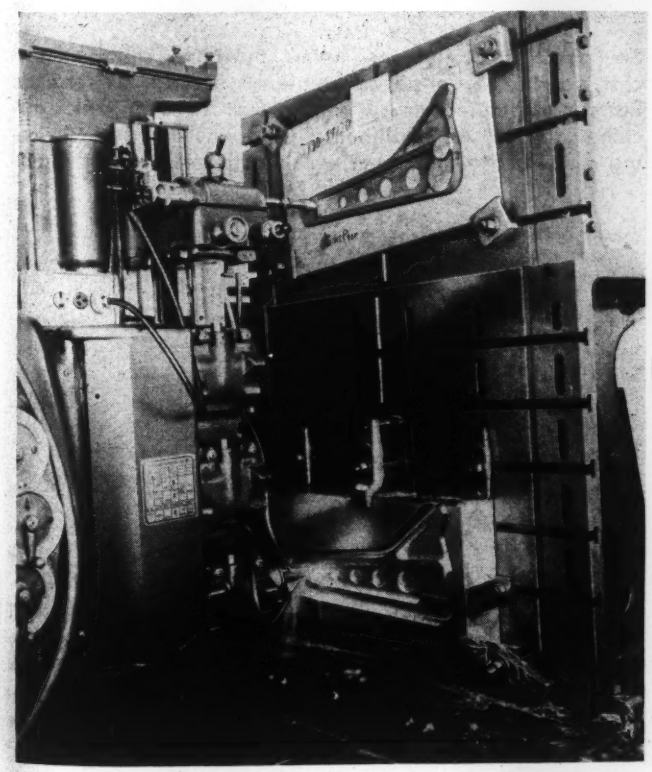
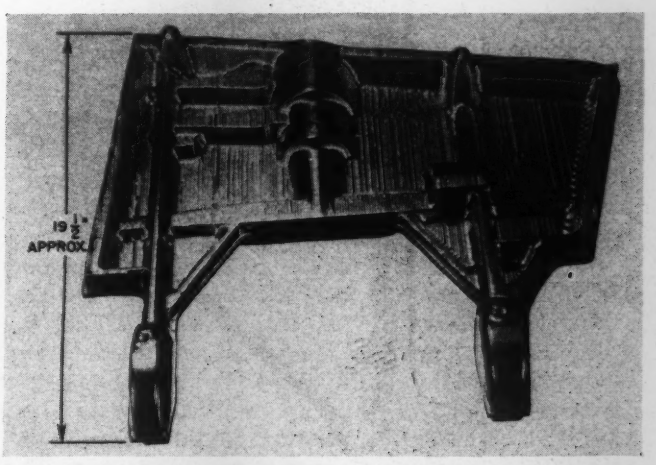
IF THE cost of a given forging die is known and prorated against the number of pieces to be produced, plus cost of final machining time, the price per piece can be fairly accurately compared to the price for machining a part from bar stock or forged billet. Unfortunately, time is sometimes an unfavorable factor, and many parts have been Kellered to shape to meet a schedule while forge dies were being built, thereby losing part of the savings possible through the use of forgings.

As is obvious, each fitting differs from all others in some respect and each requires a definite quantity as the break-even point where the forging becomes more economical than a machined bar or billet. In general, the larger the size of the fitting, the greater the forging die cost will be but, by the same token, a lesser quantity of forgings will be required to match die cost with machined bar or billet cost. Comparative appraisals of the quantity required to break even, as well as economical design considerations, should be obtained where boundary-line cases occur.

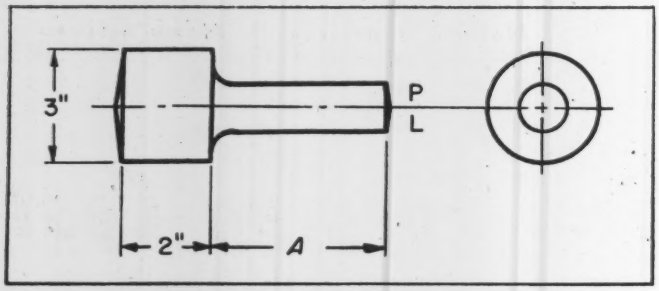
Accompanying are several parts with cost comparisons of forgings vs. machinings.



For the part shown, left, on the Keller machine, the time plus billet stock equals $227. The cost of 8 pieces produced in this manner would pay for the forging dies. Thereafter forged parts would cost $10.40 each or about one-twentieth of the Keller method



Die cost (left and right-hand)	$20,000
Ten left and 10 right-hand parts Kellered to shape	$20,000
Savings by using forgings for 100 ship contract equals approximately	$75,000

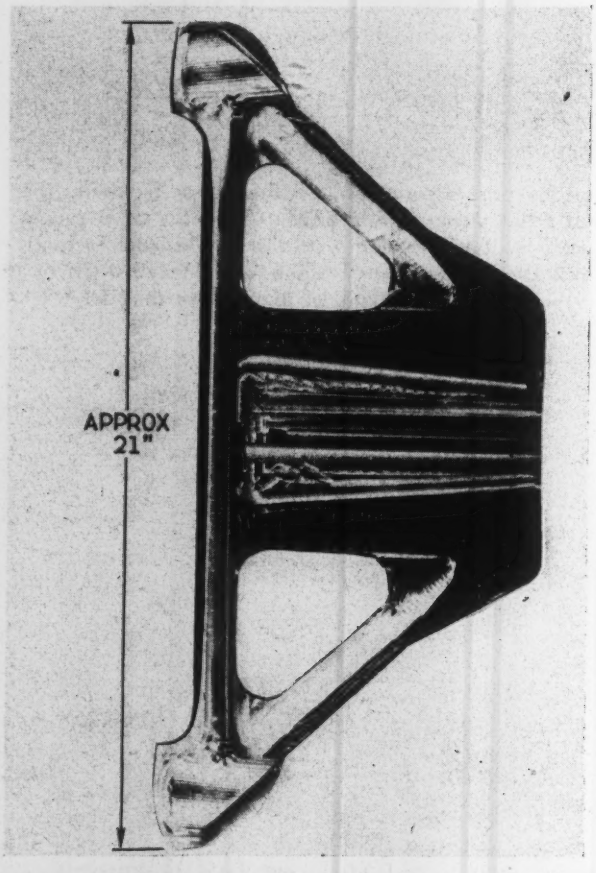


If made in aluminum alloy with length A equal to 7 inches, nearly 1000 pieces could be machined from bar stock before a die forging would pay off. This is due to the fact

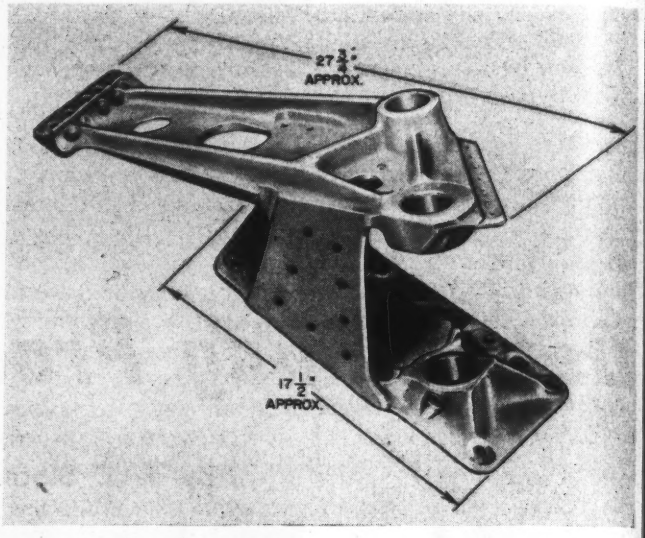
Cost per Piece

Length A (in.)	100 Pieces		200 Pieces	
	Machined	Forged	Machined	Forged
1	$2.50	$3.71	$2.30	$3.15
2	3.25	4.13	3.05	3.43
3	4.02	4.48	3.82	3.81
4	4.66	4.83	4.46	3.98
5	5.54	5.18	5.34	4.26

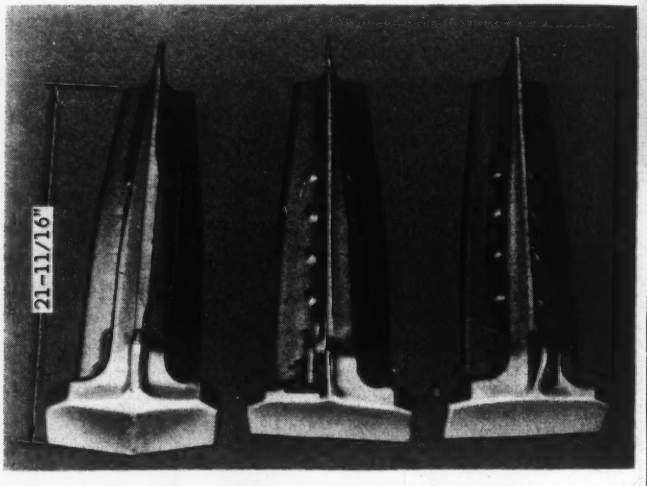
that aluminum alloy is more easily machined than steel. In practice the temperature range for forging aluminum alloy is more critical than for steel and contributes to higher piece price



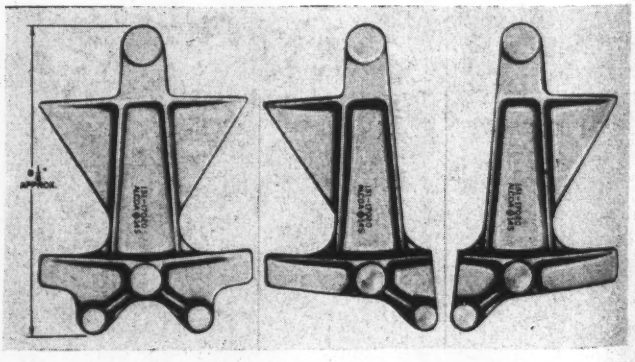
Time and material to make 17 pieces by Keller machine equals the required forging die cost



Two forgings (4340 steel) welded together. Time and material to make 7 left-hand and 7 right-hand parts by Keller machine equals the die cost. Savings by forging 33 left-hand and 33 right-hand parts equals $52,000



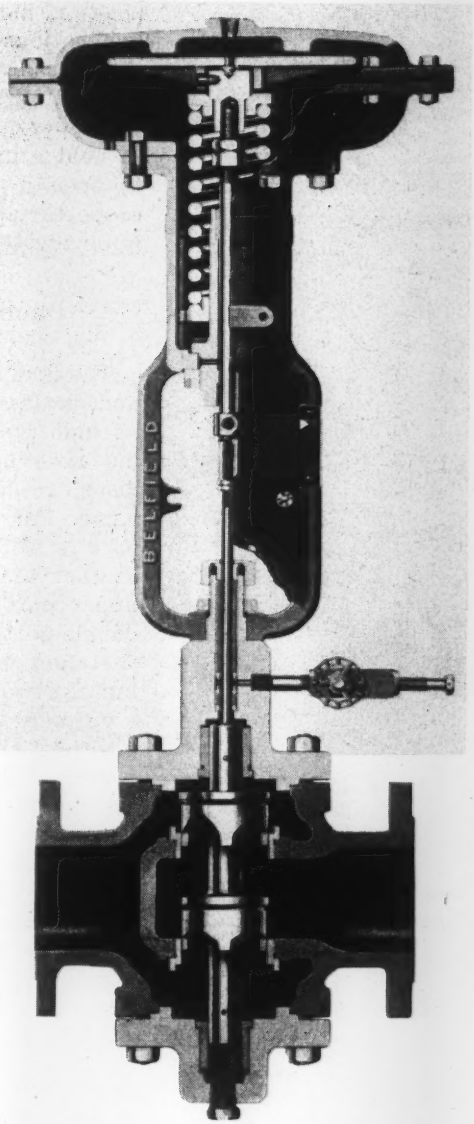
Six parts made on the Keller machine, plus material cost, equals die, set-up, and material costs for six forgings. Parts made thereafter by forging cost 1/16 of Keller machine charge. An additional $1400 was saved by designing a neutral forging from which both left and right-hand parts could be made

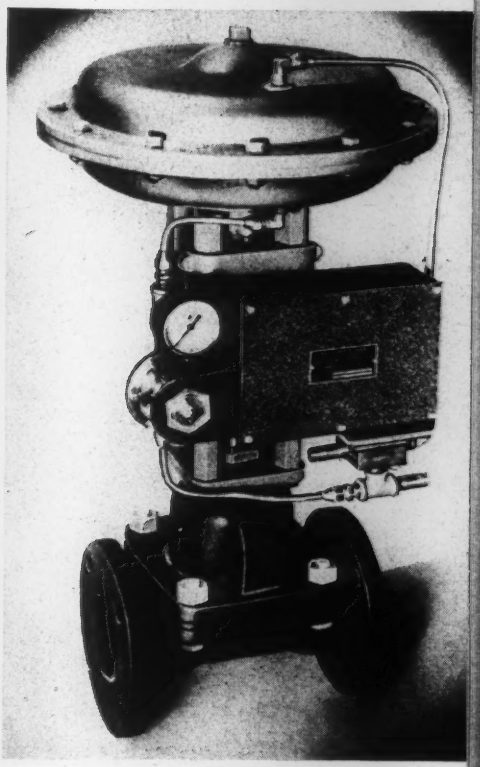


In this photo is shown a composite forging from which either left-hand or right-hand parts can be made. By using a single forge die $870 was saved. The slight additional cost of machining and material is less than one-fourth of the prorated die cost for each part over the present quantity of parts

Control Valves

Their Design and Selection





By John Procopi
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Fig. 1—Above Center—High-lift double-ported diaphragm valve of spring-opposed design

Fig. 2—Above—Springless motor operator on Saunders patent diaphragm valve

DESPITE the wide application in industry of the many types of control valves, little information has been made available which would assist designers in determining the correct valve for a specific installation. To properly apply a control valve, it is necessary to recognize its capabilities and limitations —to know what it can do and how.

A control valve may be described as a variable resistance in a fluid flow system. In any automatic control installation, it is as important a component of the system as is the control instrument. It must be capable of performing in accordance with the dictates of the controller, otherwise the installation will be unsatisfactory.

Popular types of control valves are pneumatic, hydraulic, electric or manually operated—that is, their motive power is supplied by one of these four forms of operating energy. Since the pneumatic or diaphragm motor-operated valves are much more widely employed than other types, this article is limited to design and construction features which should be considered in their selection.

POWER UNIT: Basically, the valve assembly comprises a power unit or diaphragm motor and the control valve body. Two types of pneumatically operated power units are commonly employed, namely, spring-opposed and springless diaphragm motors.

Spring-Opposed Diaphragm Motor: This power unit, *Fig.* 1, has a flexible diaphragm with a pressure-tight chamber on the upper side. A compression spring on the under side of the diaphragm creates an opposing force which, when equal to the diaphragm force, results in a balanced position of the valve disk. The ideal curve when plotting air pressure on the diaphragm versus inner valve movement is a straight line. This characteristic is essential to satisfactory control, as is low hysteresis—the difference between the valve stem position resulting from an increase in

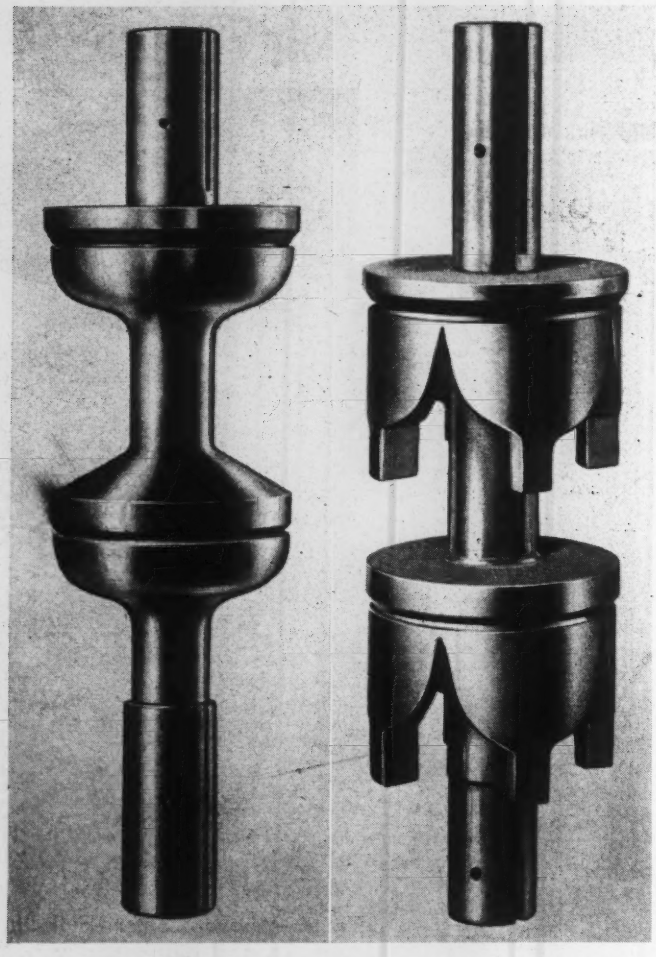


Fig. 3—Linear plugs of the solid plug type, shown at the left, and the V-port type shown at right

air pressure to a given value, and that resulting from a decrease in air pressure to the same value. Excessive friction produces a wide hysteresis loop due to the inability of the control valve to reproduce a given position when the same pneumatic loading pressure is reproduced on the diaphragm. Basically, the spring is employed to co-ordinate the valve position with the instrument air pressure but, while functioning, it absorbs the power provided by the diaphragm motor and leaves little power available to overcome the unbalance in the valve.

Springless Diaphragm Motor: There is available a springless diaphragm motor, *Fig.* 2, whose power is a direct function of effective air pressure and diaphragm area. The power-absorbing spring is eliminated in this motor and the underside of the diaphragm is loaded pneumatically with a constant pressure which can be adjusted to suit conditions. The top is loaded automatically, through a force balance type of valve positioner, to any pressure required to hold the position dictated by the control instrument. The loading on one side or the other (depending upon the direction of the thrust) can be set at a minimum, thereby making maximum differential pressure available, across the diaphragm, for overcoming thrusts.

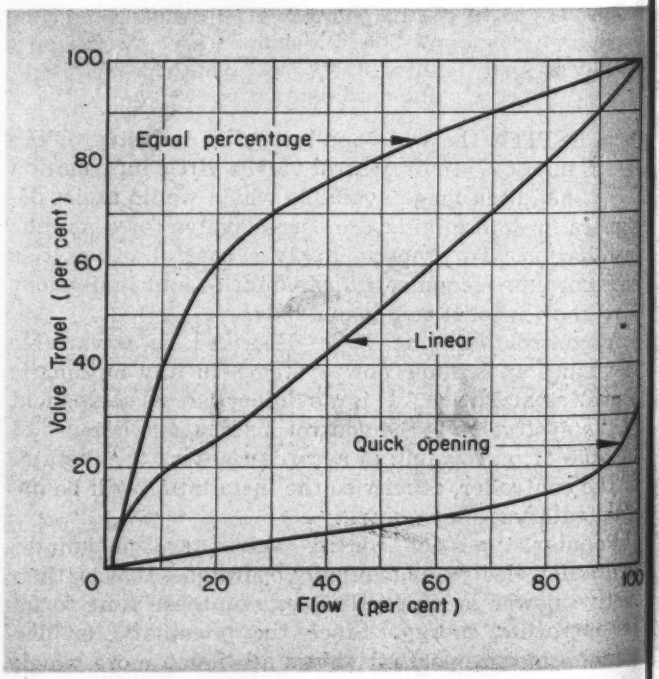
BODY MEMBER: Valve bodies are available in single or double inner port construction. In single-port valves, differential pressure acts over the entire bottom of the valve plug to create a vertical force on the valve stem. When the valve plug is in the closed position, moreover, the downstream pressure in many applications drops practically to zero. This increases the pressure differential across the valve so that the vertical thrust may constitute an appreciable force. The power unit must overcome this force in order to hold a direct acting (air-to-close) valve closed or to open a reverse acting (air-to-open) valve. For proportional control, the effect of the stem thrust is obviously undesirable.

Double Port Improves Characteristics

The double-port body was designed to minimize the undesirable effects of this thrust. The inlet and outlet fluid pressures tend to balance themselves by acting both upward and downward on the two valve disks, resulting in what is termed a semibalanced valve. For practical construction, however, the upper port is usually made slightly larger than the lower so that the lower valve disk may pass through the upper port when the inner valve is installed. The double-port construction has one disadvantage. With variation in temperature, the stem portion connecting the two valve plugs contracts or expands linearly a different amount than the valve body. In the closed position, therefore, one valve disk seats first and prevents the second disk from seating completely. This results in a minimum or "leakage" flow. Thus, when tight shut off is required, a single-port valve must be used.

INNER VALVES: Most important factor in the overall performance of a control valve is the flow characteristic which, in effect, describes the manner in which the control valve acts. The term "inherent

Fig. 4—Flow-lift characteristic curves of typical control valves with equal percentage, linear and quick-opening types of inner valve plugs



valve characteristic" is used to denote the relation between stem position and flow under constant pressure drop. When the drop or pressure differential does not remain constant, as usually occurs in service, the characteristic curve is manifestly modified to provide what is termed the "effective valve characteristic". There are three common types of inner valves: (1) Quick opening, (2) linear and (3) equal percentage.

Quick Opening: This is a bevel-seated or poppet type inner valve in which the area of the opening is determined by the perimeter of the disk times its valve lift. There are no restrictions after the inner valve leaves the seat, and the valve reaches maximum capacity at a relatively small proportion of lift. This type of valve is generally used for open-and-shut service.

Linear Plug: This inner valve is supplied either as a V-port disk or as a solid plug, *Fig.* 3. The choice of either V-port or solid plug in clean service is largely a matter of preference. The solid plug is a better selection when there is a possibility of plugging or erosion due to the presence of suspended solids in the fluid. The flow-lift plot for this plug is a straight line on rectilinear co-ordinates, giving equal volume changes for equal stem changes, regardless of per cent of valve opening, *Fig.* 4. This type of characteristic is needed where pressure drop in the system is largely concentrated in the control valve and most of the energy must be dissipated by it.

Equal Percentage Plug: As with the linear inner valve, the equal percentage disk may be either V-ported or solid, *Fig.* 5. The flow-lift will produce a constant rate of change in flow per unit change in lift at constant pressure drop, *Fig.* 4. This change is always an equal percentage greater or smaller than the flow that existed at the moment preceding the increase or decrease in lift.

In general, the equal percentage inner valve can be used to advantage:

1. Where only a small percentage of the total system pressure drop is available across the valve
2. When a control valve is in series with pumps, heat exchangers and other resistances. Here pressure drop across the valve is likely to be low at high rate of flow but high at low flow. Even with variable flow and pressure drop, the equal percentage characteristic provides uniformly satisfactory control at any point of lift in excess of clearance leakage
3. When operating conditions cannot be determined and it is necessary to install a line-size valve. It is rather difficult to oversize a valve with an equal percentage characteristic, which basically has the capacities indicated in *Fig.* 4.

MATERIALS: To be considered also are the body and trim materials that must be used or that can be used to handle the flow in question. For those unfamiliar with the term, trim applies to the lower stem, inner valve, seat rings, and stuffing box parts. Common body materials in use today and their specific applications are generally as follows:

Iron is employed up to 250 psi and 250 F, where corrosion conditions permit its use.

Cast steel is utilized where pressures may be as high as 6000 psi and where temperatures do not exceed 600 F. Again corrosion conditions must permit the use of this material.

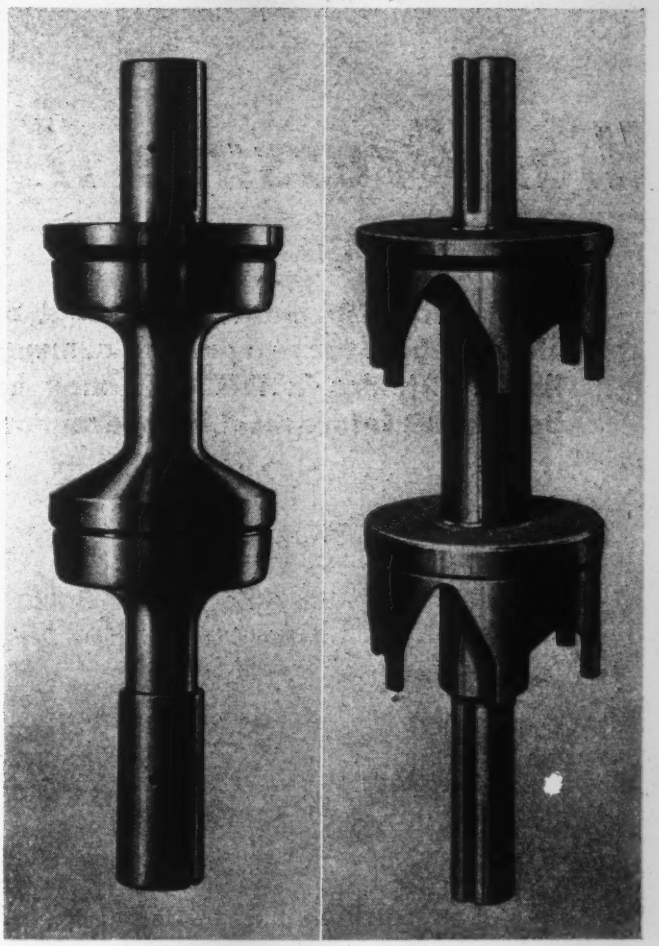


Fig. 5—Equal percentage plugs of the solid type, shown at the left, and the V-port type, shown right

Bronze is suitable for pressures up to 300 psi and temperatures not exceeding 350 F, corrosion conditions permitting.

Special alloys such as acid resisting bronze, Hastelloys and 18-8 stainless steel are also used for bodies when corrosion conditions so indicate.

Valve Trim Materials

The following are some of the more commonly used trim materials and their general fields or areas of application:

Bronze is used for situations of low pressure drop across the valve. Generally, it is not recommended for over 35 pounds pressure drop.

Stainless steel is suitable for elevated temperatures and for resisting erosion and wire drawing. The most widely used stainless is 316, an 18-8 steel with 1.75 to 2.5 per cent molybdenum.

Special Alloys such as the Hastelloys, Monel, red brass, nickel, etc., are available. Hardened stainless steel (450 to 500 brinnel) and Stellite facing on contoured plugs are used to minimize wire drawing and galling.

High-Pressure Hydraulics

. . . utilized in modern chemical processing machinery has far surpassed common present-day limits. Strides in this area may have important bearing on future machine hydraulics developments

By Roger W. Bolz
Associate Editor, Machine Design

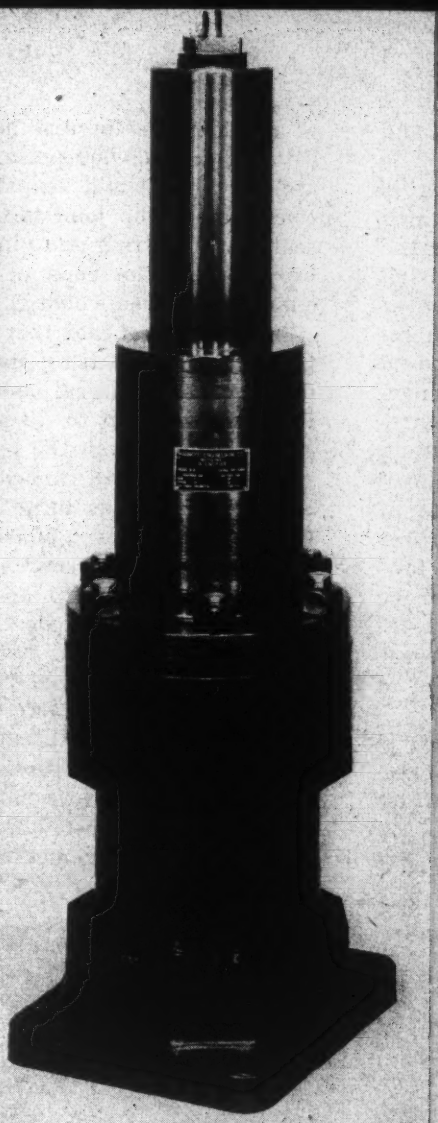
MACHINE hydraulics, in general practice, has encompassed a rather limited range of pressures. Largely as a convenience, in the interests of safety and to a considerable extent to escape possible maintenance problems, hydraulic pressures utilized and generally available through stock components have been limited to 3000 psi and less frequently to 5000 psi. Some demand for higher pressures occasionally extends this range to 10,000 psi. Bulk of the everyday applications, however, have continued to be with systems designed for 1000 psi or less.

In direct contrast to this machine hydraulics picture is that which has been growing for some time in the chemical processing equipment field. Machinery that has been gradually evolving in this area throws a new light on the hydraulics stage. Developments of recent years have brought about the need for extremely high pressures in the processing of certain materials, and systems for operation at pressures of 2000 atmospheres have come into common use. Some processes are carried out at pressures of 5000 atmospheres and others have been explored at pressures as high as 10,000 atmospheres. Prof. P. W. Bridgman of Harvard has pioneered in this work and to date has employed pressures up to 300,000 atmospheres, although strictly in very small laboratory applications.

During the recent war, pressures of 8000 to 10,000 atmospheres were regularly employed in the manufacture of big guns. In autofrettaging the gun barrels, pressures up to 10,000 atmospheres or 150,000 psi were used to accomplish this strengthening operation. Today, the Harwood Engineering Company of Walpole, Mass., is carrying on the development of comparable high-pressure hydraulic systems to make practical their use in everyday processing, *Fig.* 1. Pumps, valves, fittings, etc., for creating systems for operation at pressures up to 200,000 psi have been designed and proved in service. Some of the details of these units should prove of considerable interest to the readers of MACHINE DESIGN.

PRESSURE INTENSIFIERS: Basic design of the units for pumping the hydraulic fluid involves area-differential pistons. Termed "intensifiers," the units develop high system pressure although using only a standard low-pressure hydraulic rotary pump. High pressure is developed by introducing fluid at 1000 psi to a large-area piston and concentrating this force on a piston of small area. Pressure developed is inversely proportional to the areas, neglecting the small amount of friction involved.

In *Fig.* 2 is a view of a single-acting 150,000 psi intensifier. These units may be semiautomatic with manual reversal, or may be fully automatic with electric triggering using 4-way solenoid-operated valves. The cross-sectional design of a 150,000 psi intensifier is shown in *Fig.* 3. The taper shrink construction, a special Harwood development, utilizes compressive stresses to limit the effect of high-pressure tensile stresses produced in operation. Packings are not troublesome and are self-adjusting in operation. Design of the unit provides for renewal of packing elements without major disassembly. Capacity per



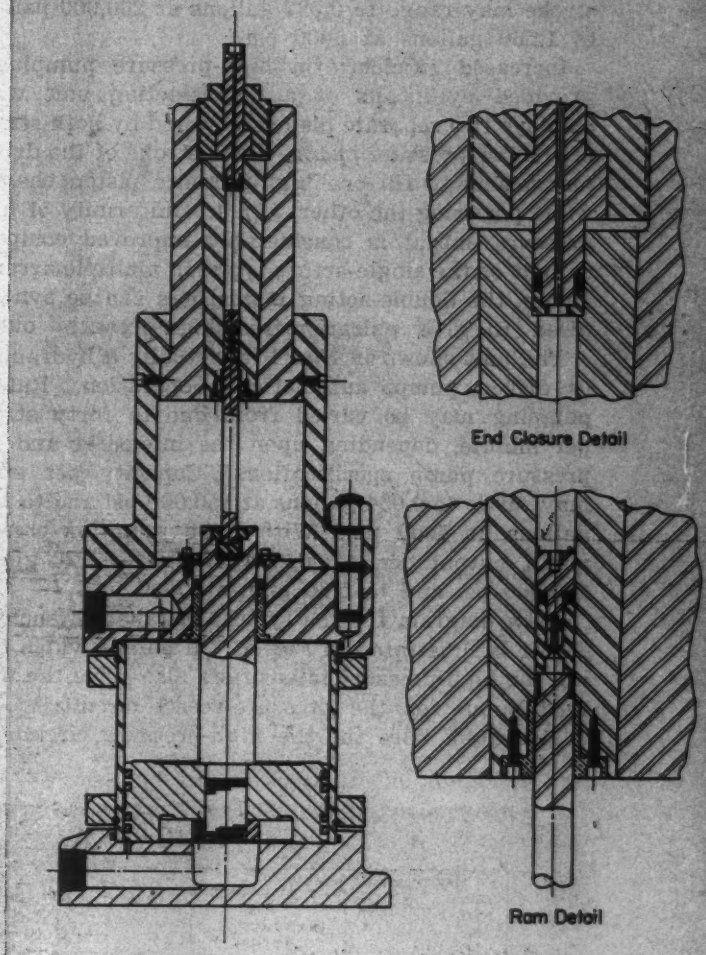
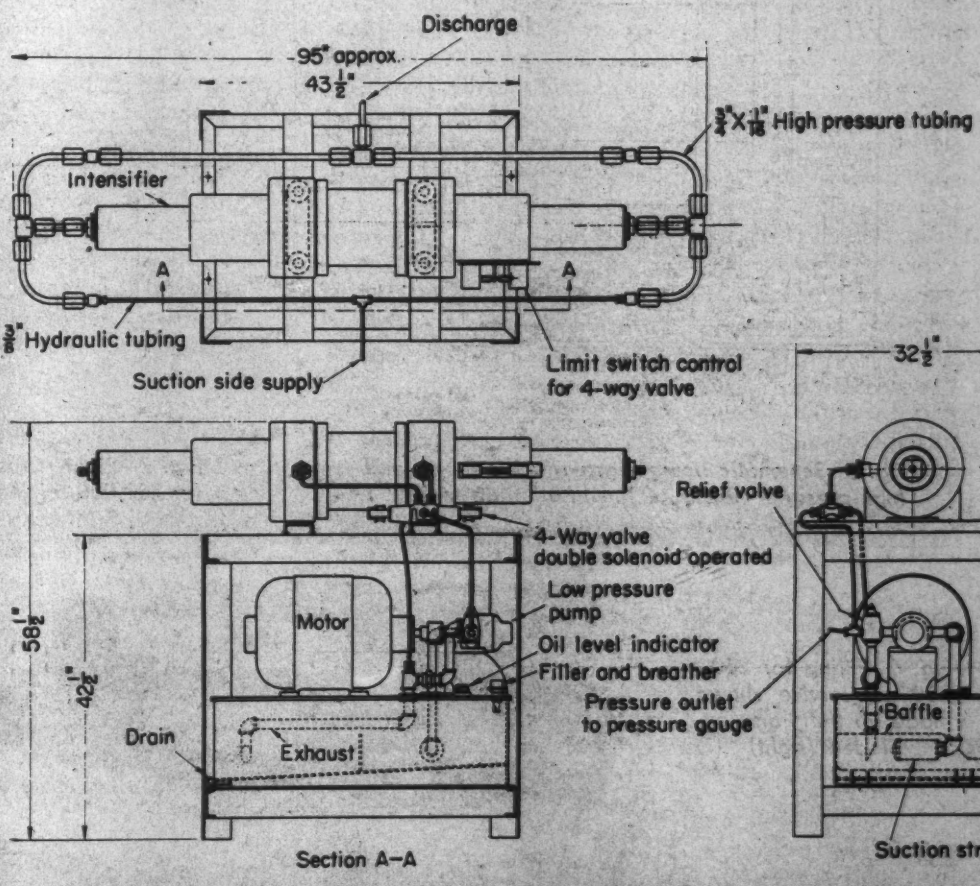


Fig. 1—Above—Typical installation of high-pressure hydraulic system utilizing pressures up to 50,000 psi

Fig. 2—Above Center—View of a single-acting 150,000 psi intensifier pump for full or semi-automatic operation

Fig. 3—Above Right—Cross-sectional design features of a 150,000 psi intensifier pump

Fig. 4—Right—Layout of a complete high-pressure hydraulic power supply including low-pressure pump and double-acting intensifier



stroke may range to 0.027 gallons at 200,000 psi, and to 1.560 gallons at 5000 psi.

Increased efficiency in high-pressure pumping is provided by means of a double-acting unit which employs two separate pistons powered by both strokes of the low-pressure piston. Each stroke of the driving piston acts to fill one high-pressure piston chamber while powering the other, *Fig.* 4. Uniformity of high-pressure output is considerably improved compared to that of the single-acting type. In multiple arrangements, the double-acting intensifiers can be synchronized to give pulsation-free high-pressure output.

The unit shown in *Fig.* 4 is virtually a hydraulically driven pump, automatic in operation. Rate of pumping may be varied from one to forty strokes per minute, depending upon the intensifer and low-pressure pump specifications. Capacity per stroke may range to 0.034-gallons at 150,000 psi and to 1.470 gallons at 5000 psi. With a 30 gpm low-pressure pump, output per stroke may range to 0.20 gpm at 150,000 psi and to 5.66 gpm at 5000 psi.

Flow diagram for the typical installation shown in *Fig.* 1 is illustrated in *Fig.* 5. Oil pumps which actuate the high-pressure intensifiers also drive the water feed pump for the pressure-vessel circuit.

Hydraulic lines for the high-pressure circuits are of considerable interest as are the fittings utilized. Fittings for 200,000 psi are shown in *Fig.* 6, "made up" on the left and "exploded" on the right. A cone connector at the joint is utilized and is held against seats in the fitting and pipe end. A threaded collar is provided on the ends of the pipe for the locking shoulder against which the heavy nut works.

It can be seen that there are both male and female threads on the fitting noses. This is to provide a more-or-less universal connector for the tubing used. For pressures up to 75,000 psi, 316 type stainless-steel tubing ¼-inch OD by 1/16-inch ID is used with the female 9/16-18 American standard thread. High-capacity tubing as large as ½-inch ID by 1½-inch OD with fittings for 50,000 psi service has also been developed. For pressures to 200,000 psi or over, a composite tubing of 1/16-inch ID and ¾-inch OD is employed with the male thread and nut shown. This tubing has a stainless-steel core over which is drawn a heavy external steel tube shield.

In addition to regular crosses, tees and elbow fittings for systems up to 200,000 psi, Harwood has also developed two and three-way valves, *Fig.* 7, check valves and other associated control units necessary for designing superhigh-pressure hydraulic control and loading arrangements.

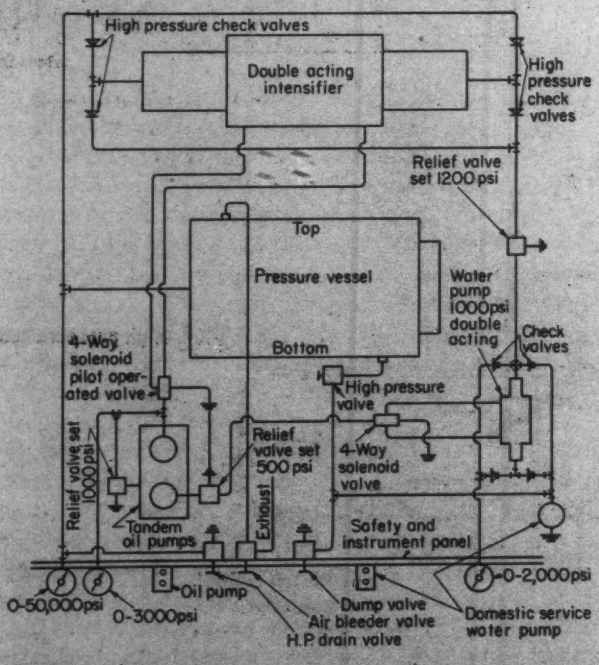


Fig. 5—Schematic flow diagram for both low and high-pressure circuits of the installation in Fig. 1

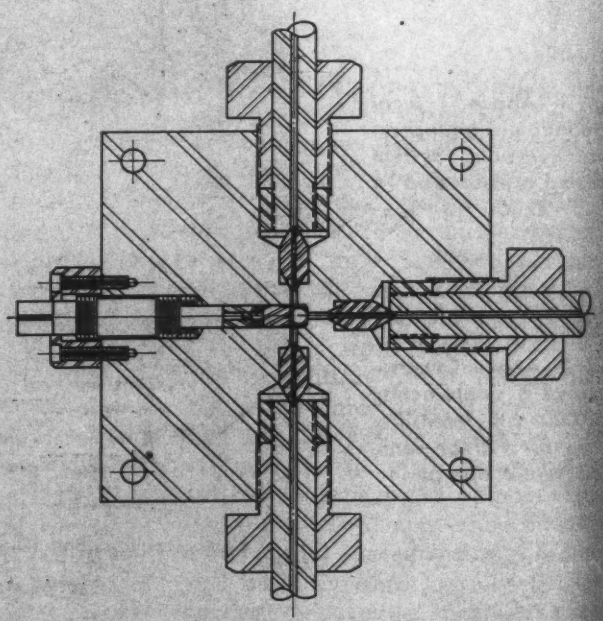


Fig. 7—Right—Cross section of a three-way valve for 200,000 psi service, showing fitting connections

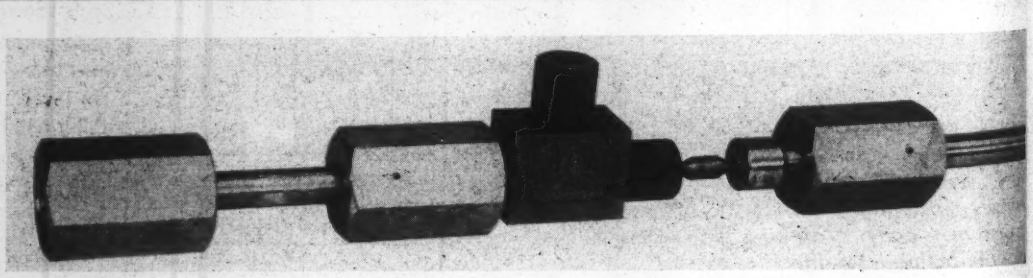


Fig. 6—Fitting for 200,000 psi service shown made up (left) and exploded (right)

Thickness and Deflection of Uniformly Loaded Flat Plates

CALCULATING thickness and deflection of flat steel plates* subjected to uniformly distributed loads is performed simply by means of the nomographs on the following pages. For circular and rectangular flat plates, of which all edges are either simply supported or rigidly fixed, the following equations apply:

$$s = K_1 \frac{wb^2}{t^2}$$

$$y = K_2 \frac{wb^4}{t^3}$$

where s = maximum fiber stress, psi; w = unit uniform load, psi; b = diameter of circular plate or width of rectangular plate, inches; t = plate thickness, inches; y = maximum deflection of plate, inches; K_1 and K_2 = constants. Introduced below, a = length of rectangular plate, inches.

Values of the constants, K_1 and K_2, are dependent upon both shape of plate and method of constraint. For rectangular plates, K_1 and K_2 are influenced also by the ratio of width to length, b/a. Built into the chart of *Fig.* 1, K_1 applies for maximum fiber stress, which occurs either in the center of the plate for certain conditions of shape and constraint or at some point or points along the edges in others. Incorporated in *Fig.* 2, K_2 applies for maximum deflection which occurs at the center of the plate for all cases. The constants are evaluated from basic expressions† with modulus of elasticity taken to be 30,000,000 psi and Poisson's ratio, 0.3.

Use of the equations and their constants, which are based upon approximate mathematical analysis, is restricted to those designs in which the least transverse dimension, b, is more than four times the thickness, t, and the maximum deflection is not greater than one-half the thickness.

How to use the chart is most easily demonstrated by practical examples.

EXAMPLE 1: Find thickness, t, and deflection, y, for a working stress, s, of 20,000 psi for a flat rectangular plate, edges fixed, 20 inches wide by 40 inches long ($b/a = 20/40 = 0.5$) subjected to a uniform load, w, of 100 psi.

On *Fig.* 1, enter the left-hand grid at $s = 20{,}000$. Proceed diagonally upward to the left as far as the vertical representing K_1 for $b/a = 0.5$ when the edges are fixed; this line is so labeled at the bottom of the grid. From the intersection of the diagonal with the vertical, return horizontally to the s scale.

Project a straight line from the new point on the s scale through the 100 point on the w scale to the t scale. From the point so determined, proceed diagonally upward to the right until intersecting the vertical representing $b = 20$. Finally, return horizontally to the t scale; $t = 0.99$. The sequence of operations is pictured on the key diagram at the lower right.

Solving for deflection, y, by *Fig.* 2 is a similar process, except that adjusted points are first determined independently on the w and t scales and y is determined by the line joining them.

Enter the left-hand grid at $w = 100$; trace diagonally to the vertical for $b/a = 0.5$, interpolating from the scale at the bottom of the grid; return horizontally to the w axis, "holding" this latter point. Similarly, enter right-hand grid at $t = 0.99$; move horizontally to $b = 20$; return diagonally to the t axis. Join this new point on the t scale to that previously found on the w scale by a straight line. Its intersection with the deflection scale gives $y = 0.015$-inch.

When all plate edges are simply supported, instead of fixed, the procedure is the same except that use is made of the b/a scale at the top of the left-hand grid in each of *Figs.* 1 and 2.

Square plates may also be calculated by means of the chart; they are, of course, simply special rectangular cases for which $b/a = 1$.

EXAMPLE 2: Find t and y of a circular plate with edges supported for $s = 15{,}000$ psi, diameter, $b = 25$ inches, $w = 50$ psi.

Proceed as for Example 1, except in the left-hand grid of each chart use the vertical marked *circular* at the top. Thickness, $t = 0.8$-inch; deflection, y, $= 0.055$-inch.

* This Data Sheet is based upon a suggestion by Mr. Carl P. Nachod, vice president, Nachod & United States Signal Co. Inc., Louisville, Ky.

† R. J. Roark—*Formulas for Stress and Strain*, McGraw-Hill Book Co., New York, 1943, Chapter 10.

Data Sheet

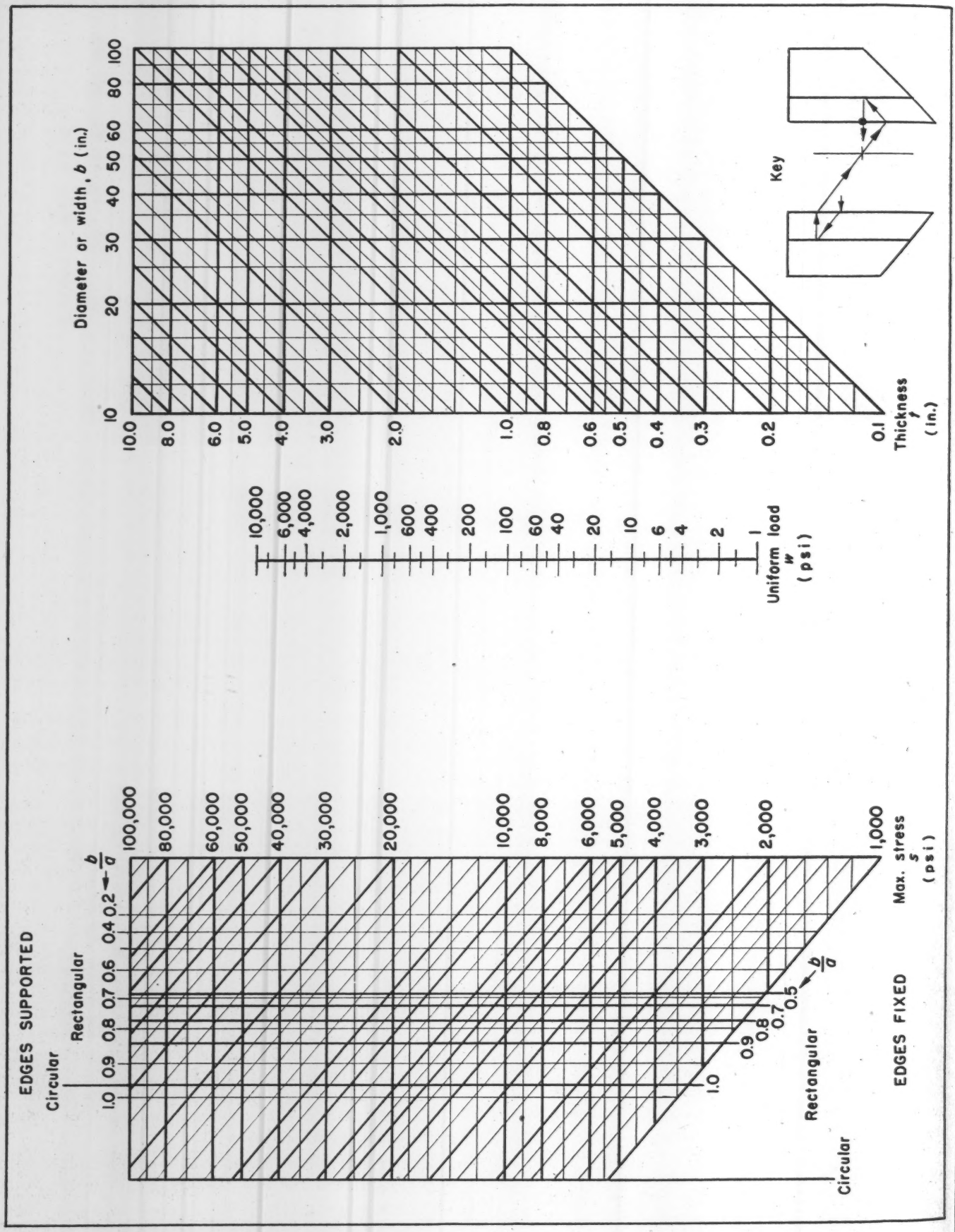


Fig. 1—Alignment chart for determining thickness of circular and rectangular flat steel plates subjected to uniformly distributed loads. For higher stress range, dimensions of both (s) and (w) scales should be multiplied by 10. For smaller plates divide (b) and (t) scale dimensions by 10

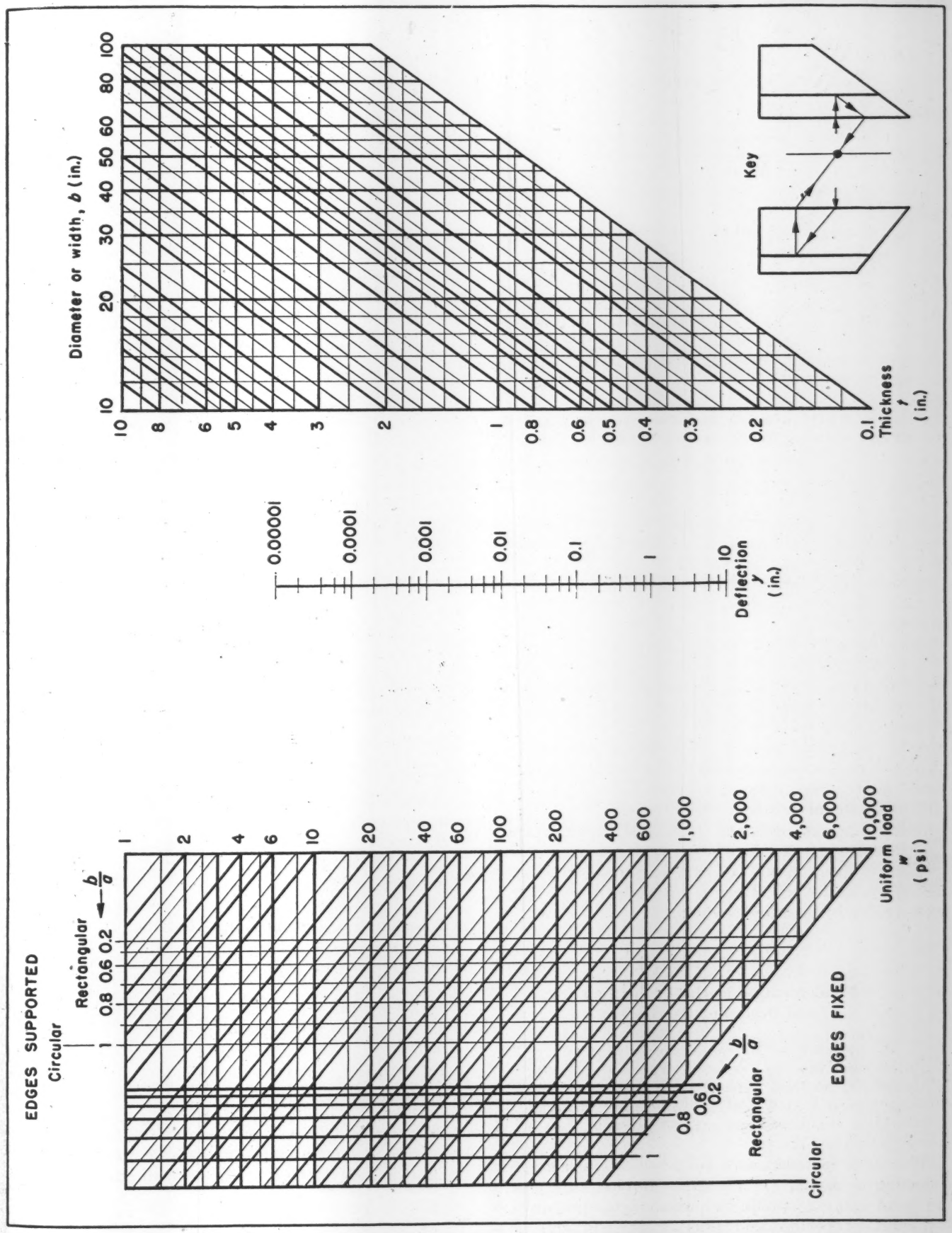


Fig. 2—Alignment chart for determining deflection of uniformly loaded flat plates. For smaller plates, divide dimensions on (b), (t) and (y) scales by 10. Calculations can be made also for square plates which are simply special rectangular cases: ratio of width to length equals one

THE ENGINEER'S LIBRARY

Analysis and Lubrication of Bearings

By Milton C. Shaw, associate professor of mechanical engineering, Massachusetts Institute of Technology, and E. Fred Macks, Lewis Flight Propulsion Laboratory, NACA; published by the McGraw-Hill Book Co. Inc., New York; 618 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$10.00 postpaid.*

Because it presents a unified exposition of the many aspects of bearing analysis, justifying by practical problems the theories advanced, this book should prove of value to the designer as a permanent reference on bearings and their lubrication.

The general principles of bearing load analysis are first developed. Dimensional analysis is then introduced to generalize the results of bearing load computations and lubrication. In each succeeding development, the external conditions imposed upon representative shaft bearings are considered in detail and integrated with lubrication theory—from the principles and problems of general hydrodynamic conditions to those of boundary conditions. In the light of increasing prime mover speeds, the chapters devoted to high-speed bearings are of particular interest. The many phenomena of these bearings and their lubrication—flow orientation, turbulence, journal mass, shaft whirl, erosion, thermal properties, etc.—should prove of interest to the designer. Rolling-contact bearings, differing from the hydrodynamic type because of the metal-to-metal contact, are also comprehensively discussed. Presentation of the various types of bearing testing machines rounds out a well-written, well-organized text.

□ □ □

Fundamentals in the Production and Design of Castings

By Clarence T. Marek, associate professor of manufacturing processes, Purdue University; published by John Wiley & Sons Inc., New York; 383 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$4.00 postpaid.*

This book should serve to assist the designer in planning a design for casting. Emphasis is placed on sand casting—production equipment, preparation of sand, properties and uses of ferrous and nonferrous metals, etc.—although a general picture of the other casting methods is presented.

Of particular interest to the designer are those chapters concerned with the actual design of parts for casting. Consideration is two-fold: Fabrication for economy and quality; elimination of defects due to the inherent characteristics of metals. Discussion of fabrication revolves around the selection of production alternatives—cast, cast-weld, weld, etc.—primarily from the quantity production standpoint. Suggestions are presented for the proper evolution of a design with the factors to be considered enumerated. The discussion of inherent defects involves the study of cast-part shapes from the standpoint of shrinkage, hot spots, isotherms, etc. Suggested designs to eliminate these defects are discussed. Both discussions—fabrication and inherent metal defects—are correlated so that the final result serves to guide design toward economy and quality.

Government Publications

Cylindrical Roller Bearings at High Speeds—I—NACA TN 2128: An experimental study of 75-mm bore cylindrical roller bearings of three cage types conducted over range of DN (bore × speed) values from 0.3×10^6 to 1.65×10^6 and loads from 7 to 1613 lb.

Significant differences in operating characteristics of three bearing types existed. The one-piece inner-race-riding cage bearing gave most reliable performance. Roller slip, in general, decreased with load and increased with speed, reaching values greater than 50 per cent at light loads for DN values over 1×10^6. The inner-race-riding cage bearing operated with cage speed greater than theoretical under certain conditions. The actual life of cylindrical roller bearings operated at DN values over 0.7×10^6 and with light loads may be appreciably greater than the predicted fatigue life based upon the sum of the external load and the theoretical value of the centrifugal load. This apparent increase in life is due to slippage within the bearing, an effect that has not heretofore been considered in such calculations.

Copies of this 54-page report may be obtained by writing to the National Advisory Committee for Aeronautics, 1724 F street, N.W., Washington 25, D. C.

Effect of Riveting on Panel Strength—NACA TN 2139: A study of the effect of variation in diameter and pitch of A17S-T4 aluminum alloy flathead rivets on the average stress at maximum load for 24S-T3

and 75S-T6 aluminum alloy, flat, Z-stiffened panels that fail by local instability. A curve is presented for determining the diameter and pitch required to insure the development of a given average stress for local instability. Copies of this 24-page report may be obtained by writing to the National Advisory Committee for Aeronautics, 1724 F Street, N.W., Washington 25, D. C.

Manufacturer and Association Publications

Fasteners Data Book: This book represents a comprehensive compilation of data on the engineering and application of industrial fasteners—nuts, bolts, rivets, screws, and special headed and threaded products. Fifty-nine reprinted articles from the Industrial Fasteners Institute's publication, *Fasteners*, form the contents. Many articles describe the results of extensive research projects conducted by industrial and technical organizations. Most phases of design and use are covered with sufficient discussion and illustration to make the book of reference value to designers. Copies of the book—206 pages, 8½ by 11 inches, clothbound—may be obtained from the Industrial Fasteners Institute, 3648 Euclid Ave., Cleveland, O., for $3.75 each.

The A-B-C's of Aluminum: The text of this 96-page, 6 by 9-inch book, which presents a general picture of the aluminum industry, is divided into three sections: Alloys, advantages, and consumption of aluminum. Essentially pictorial, it shows how aluminum is made from the raw ore, converted into sheet, rod, bar and other mill products, and finally fabricated by such operations as forming and welding. Copies of the book may be obtained by directing a company-letterhead request to the Reynolds Metals Co., 2500 South Third St., Louisville 1, Ky.

New Standards

Involute Serrations ASA B5.26—1950: This standard, replacing the SAE Serrated Shaft standard, provides a uniform, easily fabricated set of serrations that can be made by several manufacturing processes. Even diametral pitches have been adopted which are slightly coarser than the old SAE standard; the range of teeth used presents diameters both smaller and larger than the former standard so that there is a greater selection of sizes; the scope of sizes given has been increased for 40/80, 48/96, 64/128, 80/160 and the range of 32/64 moved downward to agree with the coarser pitches. The pitches included are 10/20, 16/32, 24/48, 32/64, 40/80, 48/96, 64/128, 80/160, and 128/256, complete from 6 to 100 teeth for the first three. The scope is from 0.10 to 10.0-inch diameters. The pressure angle for all serrations is 45 degrees. Serrations are based upon involute form as generated with a straight sided hob of the form included in the standard. Allowable errors and effective fits have been introduced. For easy calculation of all fits, new basic measurements between and over pins have been included, and also new tables giving the maximum tooth space and the minimum tooth thickness. This standard is available from the American Society of Mechanical Engineers, 29 West 39 St., New York 18, N. Y. for $1.00 each.

Design for Fine-Pitch Worm Gearing ASA B6.9—1950: This new standard is intended as a design procedure. It covers worms and worm gears with axes at right angles, comprising cylindrical worms with helical threads, the worm gear being hobbed for fully conjugate tooth surfaces. It supplies the standard proportions of worm and worm gears, values for all possible combinations of leads and lead angles within the standard, and tooth proportions based on normal pitch for all combinations of standard axial pitches and lead angles. An extensive table gives the difference in departure from a straight side of the worm profile and the changes in the pressure angle produced by cutters or grinding wheels of 2-in. and 20-in. diameters, the common range in use today. Examples of fine-pitch worm and worm gear calculations are included to assist the designer in using the standard. This standard can be obtained from the American Society of Mechanical Engineers, 29 West 39 St., New York 18, N. Y. for $1.50 each.

Instrumentation Flow Plan Symbols RP5.1: This is a tentative recommended practice sponsored by the Instrument Society of America who is welcoming comment and criticism. The system presented is to designate and identify instrumentation on flow plans; for recording in specifications, listings, requisitions, and other sheets; to indicate items on piping and other construction drawings; for identification tagging of equipment; and for use in technical and trade literature and drawings. The symbols and identification presented are suited primarily to the needs of the industrial process industries, although they should be adequate for use by allied industries such as steam generation, fluid materials handling, air conditioning, etc. Copies of this recommended practice may be obtained from the Instrument Society of America, 921 Ridge Ave., Pittsburgh 12, Pa. Price per copy is $1.00; discounts for purchases exceeding 20 copies.

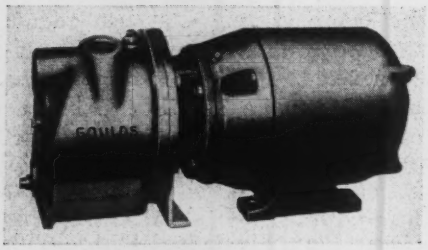
Sheet Felts, Felt Association—1950: Engineering material specifications covering mechanical sheet felts have been adopted by the Felt Association. The range of mechanical felts has been extended from the standard roll-felt specifications to include felts of similar construction which are fabricated in 36-in. square sheets. This makes possible the production of materials up to twice the density and three times the thickness possible in roll felts. Copies of this new standard and further information regarding classification, specification, properties, applications, etc., may be obtained by writing the Felt Association, 74 Trinity Place, New York 6, N. Y.

NEW PARTS AND MATERIALS

For additional information on these new developments see Page 181

Air Pump

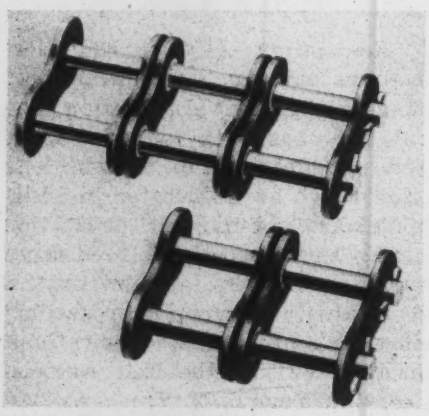
Positive displacement rotary vane type, Model C-10350 air pump is integral with motor and delivers ½-cfm of oil-free air. It has an inlet suction of 4 in. of mercury and outlet pressure of 1 in. Pump requires no external source of lubrication. It is designed to operate throughout an ambient temperature range of from —65 to 140 F. Manufacturer: Aro Equipment Corp., Bryan, O.



For more information circle MD 1, Page 181

Roller Chain Link

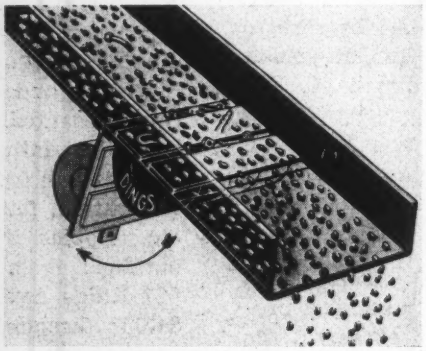
This connecting link is produced for severe service with ¾ through 2½-in. pitch multiple-strand roller chains. The link is made by pressing file-hard bushings into the pitch holes of pairs of center plates, and then grinding the bushings for hole and pitch accuracy. Wear is minimized because full support is provided across all strands of the chain and both the pins and bushings are hardened and polished. Manufacturer: Diamond Chain Co., Indianapolis 7, Ind.



For more information circle MD 2, Page 181

Magnetic Separator

Available in three magnetic field ranges, Types 1, 2 and 3 nonelectric Alnico Perma-Plate magnets are designed for removing tramp iron from wet or dry materials, to protect machinery or prevent sparks and to purify nonmagnetic substances. Lighter and more powerful than previous models, each of these types is made in 19 standard sizes from 4 to 72 in. wide and in two, four, six and eight-pole styles.

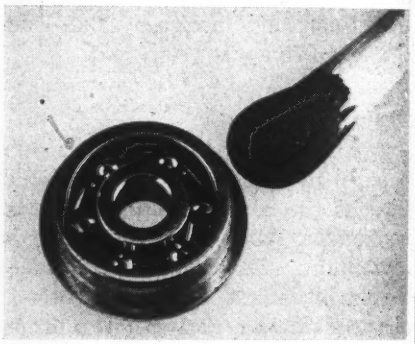


Magnets can be installed above belt and slat conveyors; in open or closed wood or metal chutes; in ducts, spouts and troughs; above and below feed tables or rolls; or integrally in hammermills, garnetts and various types of processing machinery. They are unaffected by weather or high temperatures and will handle liquids or solids. Self-cleaning models which are fully automatic are also available. Manufacturer: Dings Magnetic Separator Co., 4740 W. Electric Ave., Milwaukee 46, Wis.

For more information circle MD 3, Page 181

Small Flanged Ball Bearing

Illustrated flanged Micro ball bearing has 3/32-in. bore, 5/16-in. minor OD, 23/64-in. flange diameter and 7/64-in. width. Both the outside diameter and outer raceway are precision ground. Other sizes range from 0.055 to 3/16-in. bore and 3/16 to 5/16-in. OD and include both Conrad retainer and full-race designs. Dimensional tolerances range from ABEC1 to ABEC7. Standard construction is high-carbon chrome alloy steel, with other specifications available as special. Manufacturer: New Hampshire Ball Bearings Inc., Peterborough 1, N. H.



For more information circle MD 4, Page 181

Magnetic Amplifiers

For industrial control requirements, these magnetic amplifiers are available in three models: high-performance, high-gain and high-power. Their basic function is to pick up a weak signal and amplify it for control purposes. Features include no moving parts or contacts, high ratio of output power to control power, no need for warm-up, isolation of output circuit and input or control circuit, response to difference or sum of several signals, alternating or direct-current control and output.

High-performance series includes 28 styles with output levels ranging from milliwatts to 180 w for 60-

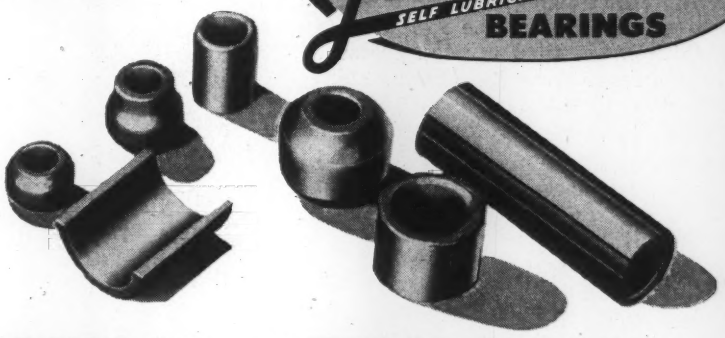
JOHNSON BRONZE

SLEEVE BEARING DATA

Ledaloyl SELF LUBRICATING BEARINGS

JOHNSON BRONZE

SLEEVE BEARING DATA

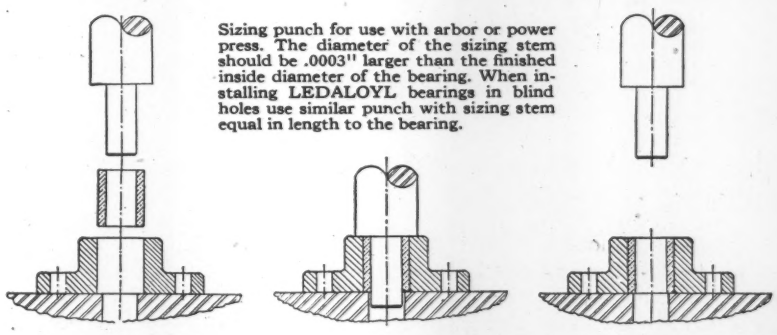


POWDER METALLURGY for Bearings and Parts

Powder Metallurgy is not a new manufacturing process . . . but its wide-spread adoption by industry is of comparatively recent origin. Bearings and parts, when produced by this method, are molded under pressure to required shape and size. This eliminates expensive machining operations and when quantities of a size are used the cost is surprisingly low. The original formula of the bronze powder consisted of approximately 88½ copper, 10 tin and 1½ graphite. In 1936, Johnson Bronze introduced LEDALOYL . . . a powder metallurgical product that conbined copper, tin, graphite and *LEAD* in the form of a PRE-ALLOYED bearing bronze. The introduction of lead as an integral part of the bronze powder provided additional bearing qualities not possible otherwise.

Manufacturers of many types of equipment gain many extra advantages through the use of Johnson LEDALOYL. One valuable feature is the self-lubricating action. Myriads of tiny, evenly spaced pores serve as miniature oil wells. When the bearing is in use the oil is metered to the shaft . . . when at rest, the oil is absorbed by these pores. This provides adequate lubrication at all times . . . preventing wear and in most cases eliminating the expense and bulk of other lubrication aids. Service records show long, troublefree operation on many types of installations.

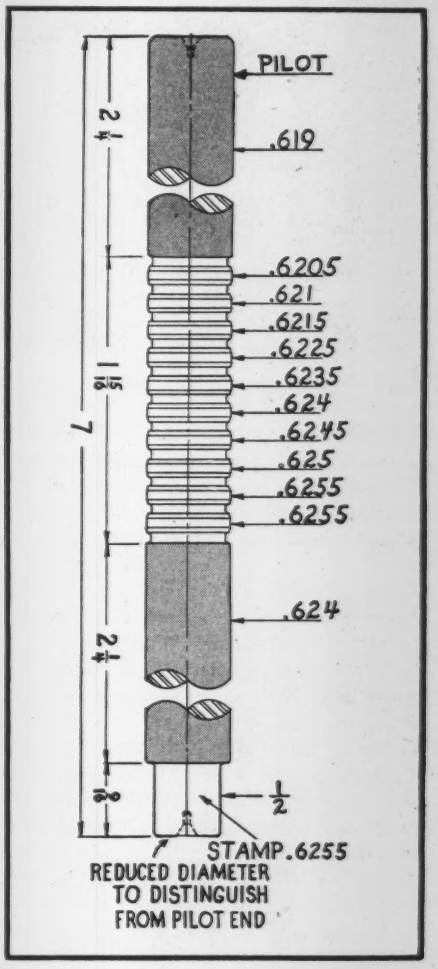
•



Sizing punch for use with arbor or power press. The diameter of the sizing stem should be .0003" larger than the finished inside diameter of the bearing. When installing LEDALOYL bearings in blind holes use similar punch with sizing stem equal in length to the bearing.

Method of Installations

LEDALOYL Bearings, correctly designed and properly installed, will usually outlast the motive unit in which they are used. We cannot place too much emphasis on installation. Absolute alignment is necessary in order to gain a low operating temperature, a short running-in period and a conservation of lubricant. The usual method of installing LEDALOYL is illustrated above. If your application is not covered in this way, we ask that you consult with our engineers. A method suitable to your application will be worked out. If your bearings are subject to excessive temperature during installation—such as in die cast applications—it is usually advisable to withhold impregnating the bearing until after assembly.



Typical Burnishing Tool

Harden, Grind and Lap, or Polish with Crocus Cloth High Speed Steel—Rockwell C-60-62.

Economy

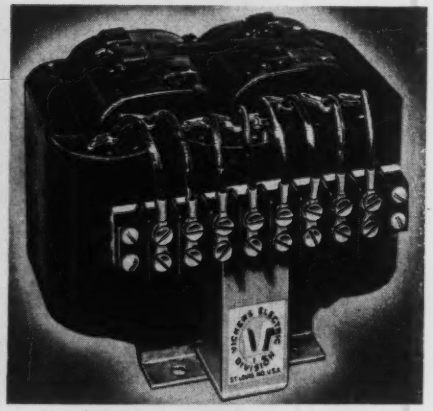
The economy of using LEDALOYL is best illustrated in producing parts other than cylindrical in shape. Flat surfaces—flanges, offsets, etc. are easily provided for in the dies and no additional machining is necessary. Johnson engineers are always available to discuss the advisability of using LEDALOYL . . . or any other type of sleeve bearing in your product. Your inquiry carries no obligation.

•

This bearing data sheet is but one of a series. You can get the complete set by writing to—

Johnson Bronze

SLEEVE BEARING HEADQUARTERS
525 S. MILL ST. • NEW CASTLE, PENNA.



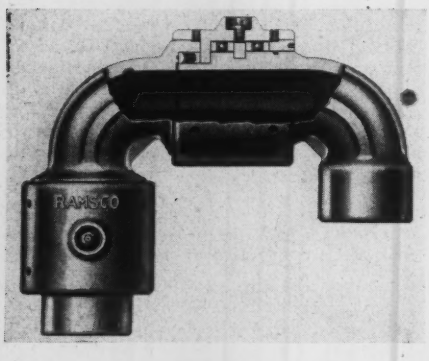
cycle power sources and 20 stock styles with maximum outputs from 30 to 385 w for 400-cycle power sources. High-gain amplifiers offer economy for 60-cycle control applications. This series is supplied in 22 styles with maximum output powers from 0.5 to 1200 w. High-power series for 60-cycle control applications includes 20 styles with power levels ranging from 65 to 3660 w.

Typical applications of magnetic amplifiers include time-delay devices, temperature regulators, servomechanisms, line-to-line voltage regulators, hydraulic transmission controls, instrument amplifiers and control relays, and speed and frequency changers. Manufacturer: Vickers Electric Div., Vickers Inc., St. Louis, Mo.

For more information circle MD 5, Page 181

Swivel Fittings

Made in single, double and triple-swing combinations, Ramsco swivel fittings can be adapted to any piping situation that requires a flexible steel swing line. They are constructed in

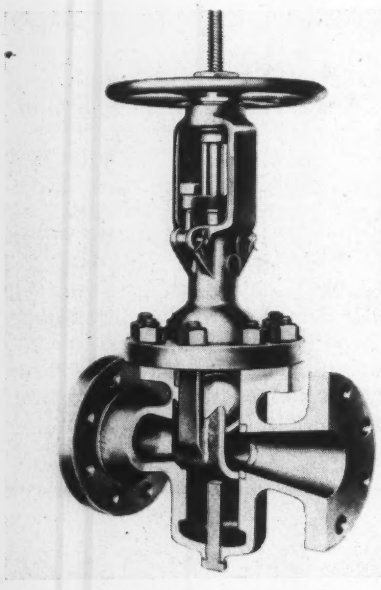


three types: high-pressure for service to 15,000 psi at 225 F; low-pressure, 1500 psi at 225 F; and high-temperature corrosive-service, 1000 psi at 750 F. Latter can handle steam; hot oil; asphalt; butane, propane or other liquefied gases; caustics and sulphuric and other acids. High-pressure and high-temperature corrosive-service fittings are available in sizes from ⅜ to 6 in.; low-pressure fittings range from ⅜ to 14 in. Manufacturer: Rasmussen Mfg. Co., 12321 Industrial Ave., Hollydale, Calif.

For more information circle MD 6, Page 181

Venturi Ball Valve

Featuring straignt-line discharge characteristics, this general purpose venturi-ball valve is especially adaptable to throttling applications in high-pressure, corrosive or erosive applications. In throttling position, ball presents smooth surface, and nonturbulent flow is possible over wide range without destructive erosion or wire drawing. When valve is

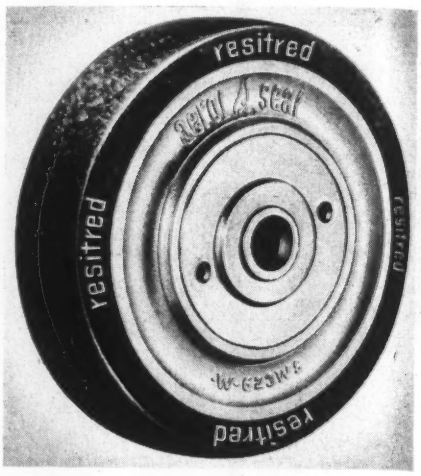


closed, ball seats tightly regardless of pressure or flow conditions. Venturi design insures self-cleaning and purging action. Wide-open flow is unobstructed with negligible pressure drop. Two seats allow reversing valve in line to double useful life. Valve is available in different materials for various service conditions. Manufacturer: W-K-M Co., Houston, Tex.

For more information circle MD 7, Page 181

Industrial Wheel

Composed of macerated canvas duck impregnated with phenolic resin, Resitred wheel tread material is formed under pressure in precision molds to insure perfect concentricity and balance. The tread is resistant



to all common fats, acids and greases and is permanently bonded to the aluminum alloy hub to withstand high loads. Features include sparkproof qualities, natural sound absorptive characteristics and ample resilience. Tread is available on Aerol, Aerol-Seal and Airlite wheels. Manufacturer: Aerol Co., 2820 Ontario St., Burbank, Calif.

For more information circle MD 8, Page 181

Plastic Insulation

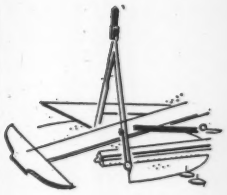
Having electrical properties comparable to those of polyethylene, Rulan flame-retardant plastic electrical insulation will neither burn after flame has been removed nor drip when molten. It has a dielectric constant of 2.7 and a power factor of 0.002 over a wide range of frequencies. Material is nontracking and retains its electrical properties after immersion in water at elevated temperatures for long periods of time. It can be extruded onto wire at high speeds and injection molded. Manufacturer: E. I. duPont de Nemours & Co., Wilmington 98, Del.

For more information circle MD 9, Page 181

Conveyor Belting

Recommended for mechanized handling of hot or highly abrasive metal parts and forgings as well as wet or dry chips and flash, this hinged-steel conveyor belting can be assembled into almost any required length or width from stock parts. Steel plate links are fastened by means of high-carbon steel rods so that the side chains become an integral part of the belting. Outside links incorporate side wings which remain positively engaged at all times. Design minimizes fall-through of materials

How to Cut Maintenance Costs ON YOUR MACHINES!



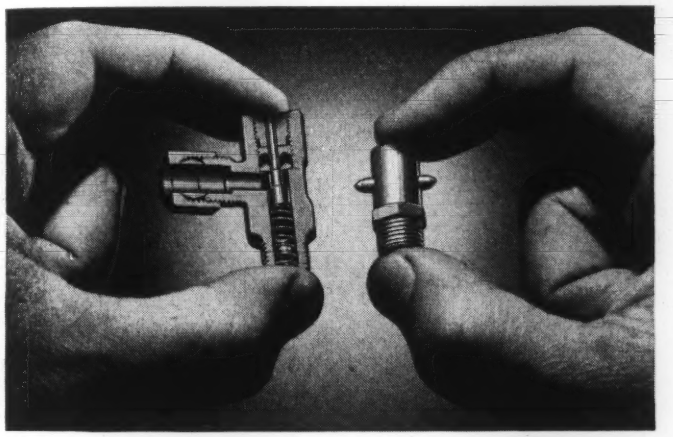
● Even the best machine design is bound to become a costly headache—unless it gets the exact lubrication it requires. Now you can assure your machines the correct *automatic* lubrication you know they require—*in advance*—with an Alemite Centralized Lubrication System.

Maintenance costs, repairs and "downtime" for lubrication can be designed right out of any machine—big or small, simple or complex. And at the same time, Centralized Lubrication can assure more production time at a lower cost per hour from every machine you design.

Since no one system suits every machine, Alemite has developed, tested *and factory-proved* 3 different automatic systems of Centralized Lubrication. Now available with manual or time-clock control, these completely enclosed, hydraulic pressure Systems eliminate the human element of error. From one safe, centralized point, your machines can receive dependable, positive lubrication keyed to their specific requirements.

Free catalogues on any Alemite Centralized Lubrication System are available upon request. If you prefer, an Alemite representative will conduct an informative, desk-top demonstration of these systems with actual models, at your convenience. Write to Alemite, Dept. R-90, 1850 Diversey Parkway, Chicago 14, Illinois.

Alemite Offers These 3 Factory-Proved Answers...



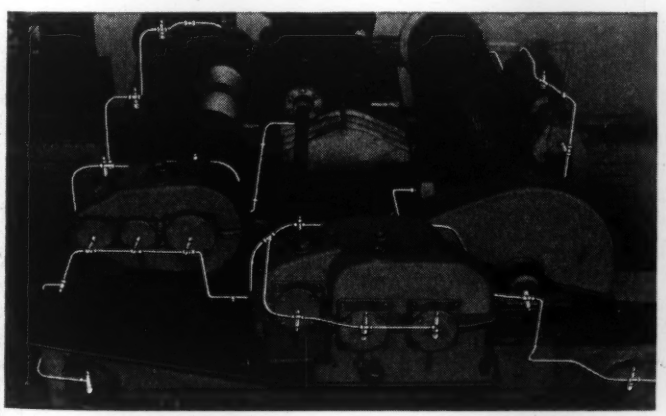
1 Alemite "Midget" System—slightly larger than a pin-type fitting, this Alemite "Midget" measuring valve is readily applicable to all types of heavy, light and precision machinery. Its simple, compact design makes it especially suitable wherever space limitations are encountered. Mounted on or near the bearings, the Alemite "Midget" delivers a measured amount of oil or grease from one central point. Can be installed for either manual or automatic operation.

ALEMITE

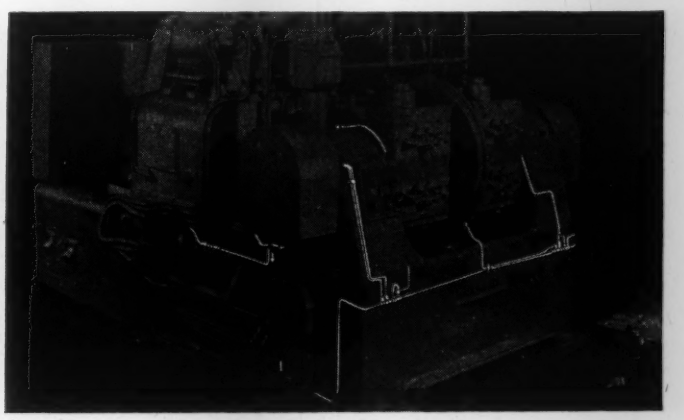
REG. U. S. PAT. OFF.

Modern Lubrication Methods That Cut Production Costs

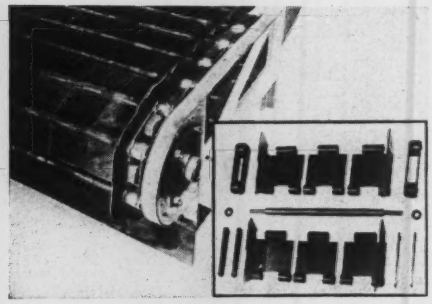
Another Product of STEWART WARNER



2 Alemite Single Line Terminating System...applicable to heavy or light machines, precision machines, outdoor installations. It is a single lubricant line, hydraulically operated system for oil or grease. Valves can be installed on or near each bearing. A measured amount of lubricant, large or small, is conveyed to each bearing from one central point while machine operates. An indicator signals when job is done. Choice of manual or automatic operation.



3 Alemite Single Line, Reversing System is ideal where excessive dirt and moisture is a problem. The system is completely enclosed, fully hydraulic. Each valve delivers a metered amount of oil or grease to two bearings. The lubricant flows *progressively* to each bearing while the machine is producing . . . an indicator at the point of introduction signals when lubrication is completed. Designed for manual or automatic operation.

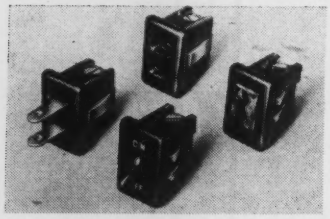


handled. Individual steel links in pitch sizes of 2½, 4, 6 and 12 in. are employed. These links are assembled to form belting in widths from 6 in. to 6 ft in any length. Working loads up to 300 pounds per lineal foot can be handled. Links can be solid or perforated to permit drainage of fluids. Manufacturer: May-Fran Engineering Inc., 1700 Clarkstone Rd., Cleveland 12, O.

For more information circle MD 10, Page 181

Electric Controls

All items in the improved Diamond H Snap-In line of electrical controls and devices have wider overlap around $\frac{31}{32}$ by $\frac{17}{32}$-in. installation holes. This eliminates need for precise fin-



ishing around holes and effects neater appearance. Contacts are held together under positive spring pressure to insure firm connection in 'on' position. Switches include 15 and 20-amp 125-v ac ratings. Manufacturer: Hart Mfg. Co., Hartford, Conn.

For more information circle MD 11, Page 181

Socket Pipe Plug

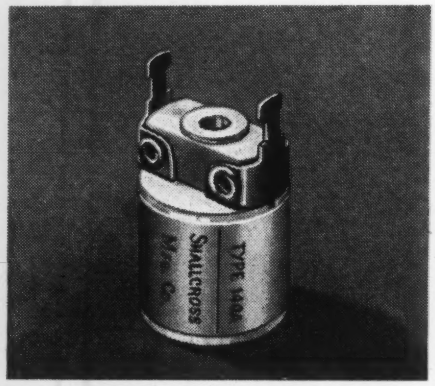
Alloy steel, brass and aluminum, hexagon-socket pipe plugs with Dryseal threads are available in 1/16, ⅛, ¼, ⅜, ½, ¾, 1, 1¼, 1½ and 2-in.

sizes. Dryseal thread, standardized by SAE, is designed to eliminate leakage without the use of sealing compounds. Seal is accomplished by metal-to-metal contact produced by truncation of the major diameter of the internal thread and the minor diameter of the external thread. Manufacturer: U. S. Plug & Fitting Co., 501 High Ave., Cleveland 15, O.

For more information circle MD 12, Page 181

Precision Resistors

Designed for JAN requirements, these improved vertical-style wirewound resistors can be used where terminals are desired at the same end of the resistor. Units provide

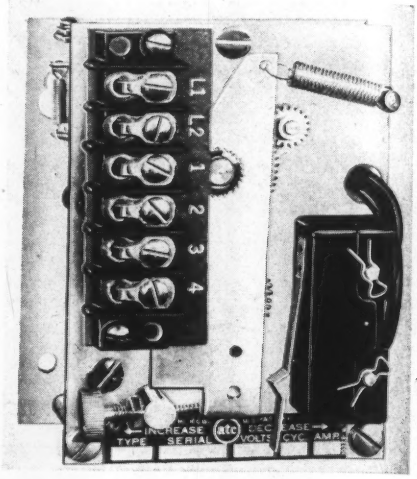


longer leakage path from mounting screws to terminals. Types BX120, BX140 and BX160 meet JAN requirements for styles RB40B, RB41B and RB42B, respectively. For commercial uses, resistors carry somewhat higher ratings than for JAN applications. Overall dimensions and maximum resistance ratings are same as standard Akra-ohm precision wirewound types. Wire leads instead of terminals can be furnished if desired. Manufacturer: Shallcross Mfg. Co., Collingdale, Pa.

For more information circle MD 13, Page 181

Resetting Delay Timer

Model 5600 resetting delay timer can be used with such electrical and electronic applications as elevator and machine-tool controls, tube protection and signal systems. It is powered by a Telechron synchronous motor and utilizes a tripping arm which is driven through a train of machine-cut spur gears. Snap-acting single-pole double-throw switch, which either opens or closes auxiliary circuit, is rated 10 amp on 115-v ac noninductive load. Motors for operation on 115 or 230-v, 25, 50 or 60-cycle current, are available. Instantaneous resetting is performed by means of an electromagnet which clutches and declutches a trip lock-



ing gear. Standard ranges from 0.75 second to 30 minutes are offered. Manufacturer: Automatic Temperature Control Co., 5212 Pulaski Ave., Philadelphia 44, Pa.

For more information circle MD 14, Page 181

Small Air Cylinder

Fast uniform power for holding and locking is provided by vertical micro air cylinder for use where size and space limitations are factors. It has threaded nose with jam-nut lock for underneath jig installations. Piston has a ⅝-in. stroke with equal ram

pressure at any stroke point and delivers 75-lb thrust with 100-psi line pressure. Cylinders are machined from solid brass stock, and any number of units can be operated by a single control valve. Manufacturer: Air-Mite, 2651 W. Lake St., Chicago 12, Ill.

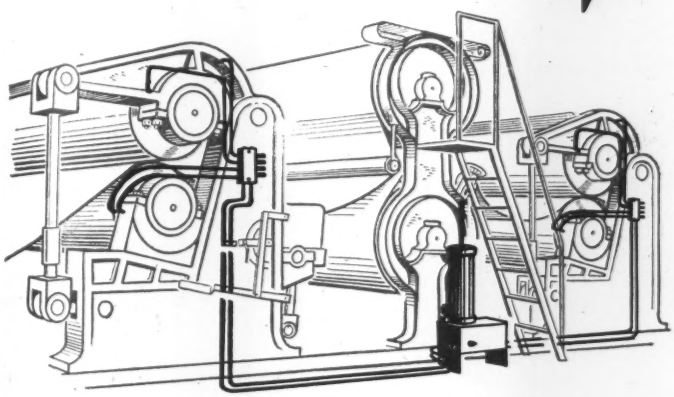
For more information circle MD 15, Page 181

Two-Watt Potentiometer

Of molded composition with linear taper and short screw-driver shaft, type AB two-watt locking shaft potentiometer is recommended for industrial applications where resistance

18% less h.p. load with Farval lubrication

FARVAL—*Studies in Centralized Lubrication* No. 112



IN the manufacture of paper, as the wet pulp travels through the rolls of the Kamyr press, pressures run up to 2700 pounds per inch. Lubrication by hand is usually accompanied by a noticeable power drag. Lubricant is wasted and shutdowns for bearing repair invariably follow.

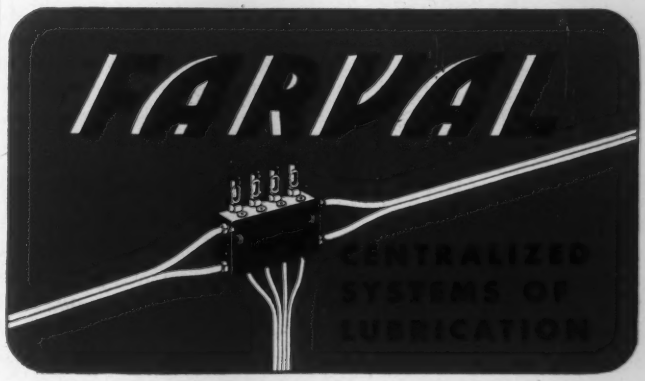
To insure continuous, uniform lubrication of its Kamyr press, a Canadian pulp mill installed Farval Centralized Lubrication. An immediate reduction of bearing friction brought a substantial reduction in power consumption. In fact, recording charts on the press show that when the Farval system was installed the horsepower load dropped as much as 18%.

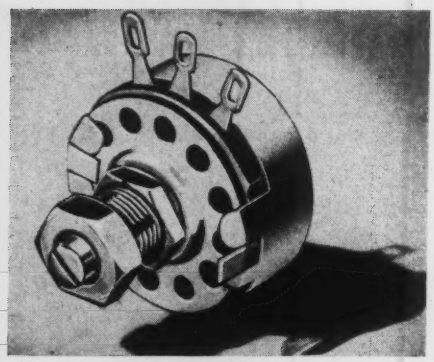
On these press rolls, as on hundreds of other rolls—calendar stacks in paper mills—rubber mills—steel and brass rolling mills—Farval has proved its ability to save power, oiling labor, lubricant and bearing expense. Most important of all, it reduces downtime and increases production.

Farval has proven itself in over 20 years of service. It is the original Dualine system of centralized lubrication that others imitate. The Farval valve has only 2 moving parts—is simple, sure and foolproof, without springs, ball-checks or pinhole ports to cause trouble. Through its wide valve ports, and full hydraulic operation, Farval unfailingly delivers grease or oil to each bearing—as much as you want, exactly measured—as often as desired. Indicators at every bearing show that each valve has functioned. For a full description, write for Bulletin No. 25.

The Farval Corporation, 3265 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.





adjustments are infrequent. Solid-molded resistance element is unaffected by heat, cold, moisture or length of service. It can be obtained in 16 resistance values from 50 ohms to 5 megohms, has a 1 1/16-in. diameter and extends 9/16-in. behind panel. Manufacturer: Ohmite Mfg. Co., 4974 W. Flournoy St., Chicago 44, Ill.

For more information circle MD 16, Page 181

Mechanical Drives

Characterized by a detachable escapement mechanism, these mechanical drives require less than 2 in. between plane of driven chart and mounting ring. Main arbor fits standard chart hub and is tied directly to mainspring. Drive is self-starting and direction of rotation is optional.

Model 24-1 has 24-hour wind, and torque drops only from 8.6 to 4.7 lb-in. between full wind and 24-hour rundown. Larger model 24-3 has 8-day wind and basic 24-hour rundown. Turrets which snap on main arbor are available to convert to rotations of 2, 3, 4, 6, 8, 12, and 48 hours and 3, 7 and 8 days. Both models wind through hub.

Escapement subassembly controls mainspring action through simple connecting square. Standard escapement allows connecting square to turn once per hour. Special escapements can be obtained for speeding up chart drives so that indicated ½ or ¼-hour ranges are traversed in 1 minute. Manufacturer: Pittsburgh Equitable Meter Div., Rockwell Mfg. Co., Pittsburgh 8, Pa.

For more information circle MD 17, Page 181

Bearing Temperature Control

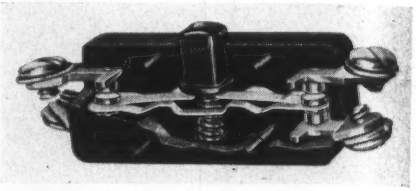
Giving remote indication of bearing temperatures in Fahrenheit and Centigrade, Simplytrol contact meter-relays sound alarm, shut down machine or apply corrective factors automatically in the event of temperature rise. Enclosed in a surface or flush-panel mounting cabinet, the

control unit consists of a transformer and a rectifier power supply for relays, load relay and other equipment necessary for a particular installation. Separate meter with thermocouple is used for each bearing or other point to be monitored. Meter contacts operate directly into load relays with contacts rated 15 amp 115 v. Both open-circuit and closed-circuit switch-type controls are available in various ranges from —75 to 2500 F. Control illustrated has five meters for controlling the bearings on a high-speed motor-generator set. Sixth meter on panel indicates running time in hours. Manufacturer: Assembly Products, Inc., Chagrin Falls, O.

For more information circle MD 18, Page 181

Snap-Action Switch

Fast snap action of this line of precision switches insures minimum arcing and long contact life. Compact, small in size and lightweight, these units have the switch mechanism enclosed in a molded plastic case.

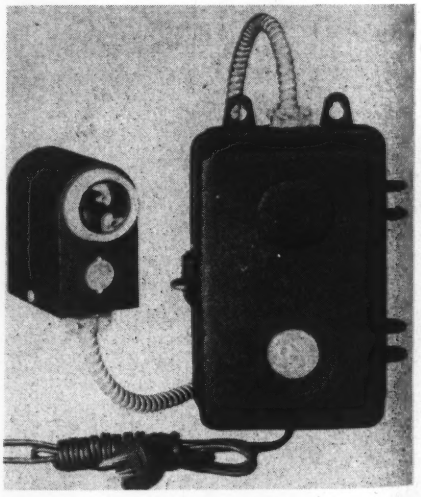


Single-pole double-throw, the switch can be wired for two-circuit, normally open or normally closed applications. A wide variety of protective metal housings, such as splashproof and general-purpose, adapt switches for control, limit and safety uses. Manufacturer: Exhibit Supply Co., Electro-Snap Div., 4218-30 W. Lake St., Chicago, Ill.

For more information circle MD 19, Page 181

Photoelectric Counter

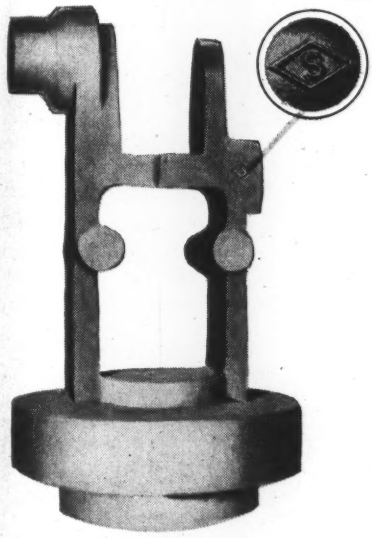
Type P-1 photoelectric counter consists of type 20 AP5 control, type 40 AC1 light source and type C-36 counter. The only equipment that needs to be located at the point-of-count is the control and light source. One or more electric counters may be placed at any convenient location and wired to the control. Applications include counting of small, fragile objects not heavy enough to actuate mechanical counters, freshly painted objects and heavy products that would damage mechanical counters. Features of the photoelectric unit and the light source are: Operating range between unit and light source, six feet—



special light sources are available for longer ranges; speed of operation, 600 counts per minute—beam must be completely broken during counts and completely restored between counts for a period of not less than 1/20 second; weight, 7½ lb. Features of the electric counter are: Power consumption, 10 watts maximum; speed

watch out for spots

You don't have to be Frank Buck to know that spots on a large cat spell danger. But unseen spots or flaws in a casting are just as dangerous. That's why Sivyer uses every scientific method known to seek out and eliminate casting spots or flaws that cause trouble in a casting. Zyglo, Magnaflux, Gamma ray inspection, plus complete laboratory control — all unite to keep a constant vigil over the development of a flawless casting, making sure that the integrity of the metal, the machined surface, and the precision shape of each casting can be pronounced safe — with the final stamp of the Sivyer Ⓢ.



A spot that identifies better steel castings

You don't have to be an expert "tracker" to recognize the "sign" of a fine casting — it's there for all the world to see — the inimitable Sivyer Ⓢ.

SIVYER

SPECIALISTS IN HIGH ALLOY AND SPECIFICATION STEEL CASTINGS

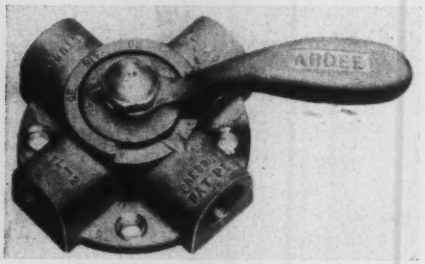
SIVYER STEEL CASTING COMPANY • MILWAUKEE Ⓢ CHICAGO Ⓢ

of operation, 600 counts per minute; maximum number of counts before returning to zero, 999,999; adjustment, reset knob for return to zero; operating position, mounted in any position and as remote from the counting location as desired; weight, 1.25 lb. Manufacturer: Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.

For more information circle MD 20, Page 181

Four-Way Valve

Noninterflow characteristic of the Ardee manual 4-way valves makes them especially applicable where infinitely variable throttling is desirable such as on handling equipment, road machinery, etc. These units control 150-psi air pressure and handle liquids up to 1000 psi; pipe sizes range from ¼ to ¾-in. Valve bodies, depending on service, are either aluminum or brass, and molded tubular sealing members of different resilient materials are available according to service requirements.

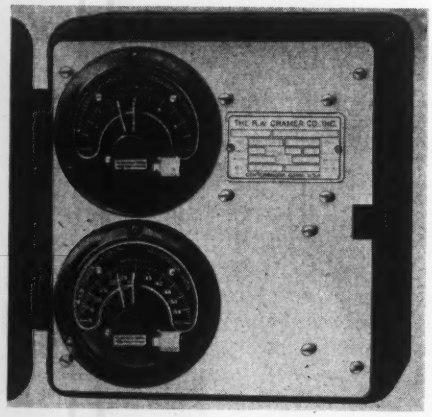


In operation, a tubular sealing member slides over the peripheral surface of a rotor, maintaining intimate contact during operation. Wiping action of the sliding seal prevents pipe scale and foreign material from lodging between the sealing surfaces. There is a minimum pressure loss through the valve because the internal flow passages are of the same diameter as the nominal pipe size and are unobstructed. Manufacturer: Barksdale Valves, 4905 Sante Fe Ave., Los Angeles, Calif.

For more information circle MD 21, Page 181

Duplex Cycle Timer

When energized, type DU duplex cycle timer will open and close one or two load or control circuits either continuously or will complete one cycle and stop. Opening of one circuit is followed by closing of the other circuit and vice versa. On and

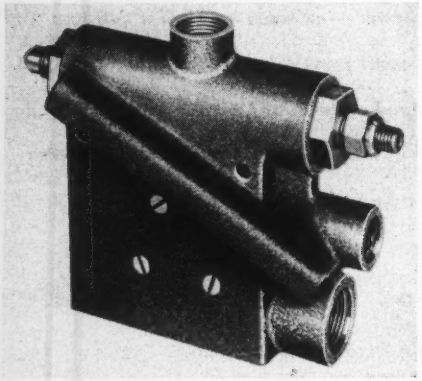


off periods can be adjusted independently of each other by means of separate knobs and dials. Eleven different dials ranging from 15 seconds with ¼-second scale divisions to 6 hours with 15-minute divisions are available. Single-pole double-throw switches have silver contacts and are rated 10 amp on 115 v. Manufacturer: R. W. Cramer Co., Centerbrook, Conn.

For more information circle MD 22, Page 181

Hydraulic Pressure Control

Designed for precise control by means of hydraulic pressure actuation, this cartridge-type electric switch will cut in and cut out electric circuits with as little as 12 to 18 per cent pressure differential. Unaffected

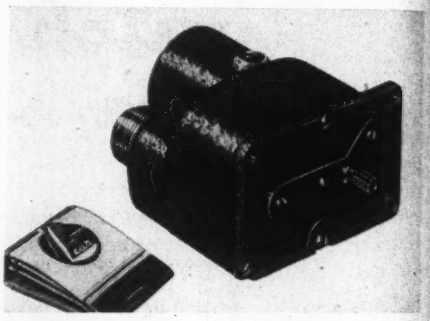


by pressure surges, unit will withstand temperatures ranging from —65 to 160 F without loss of accuracy. It will not fail from mechanical or hydraulic shock. It operates immediately with every start of pump and requires no pressure build-up. Small, lightweight and silent, the switch is quickly and easily adjusted without breaking line. Switches with preset limitations can be obtained. Manufacturer: Pantex Mfg. Corp., Hydraulics Div., Box 660, Pawtucket, R. I.

For more information circle MD 23, Page 181

Rotary Actuator

Weighing less than 1 lb, Model 167A rotary actuator can develop a maximum peak output of 110 in-lb and requires less than 1 second for full 90-degree shaft rotation under its normal rated peak load condition of 60 in-lb. Actuator shaft speed varies over operation cycle so that valve closing begins at high speed but actual shutoff takes place at slow speed to minimize ram effects in hydraulic system. Unit incorporates adjustable slip clutch which compensates for possible hydraulic surge loads. Positive mechanical stops are used, and provision can be made for



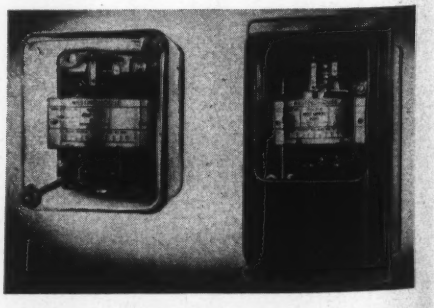
manual operation in event of power failure. Integral 26-v d-c split-series motor is rated for an intermittent duty cycle of 1 second on and 5 seconds off. For fuel, oil and pneumatic valve applications, the actuator can also be used with heat and hydraulic control valves, locking controls, dampers, etc. Manufacturer: Lear Inc., Electro-mechanical Div., 110 Ionia Ave., N. W., Grand Rapids 2, Mich.

For more information circle MD 24, Page 181

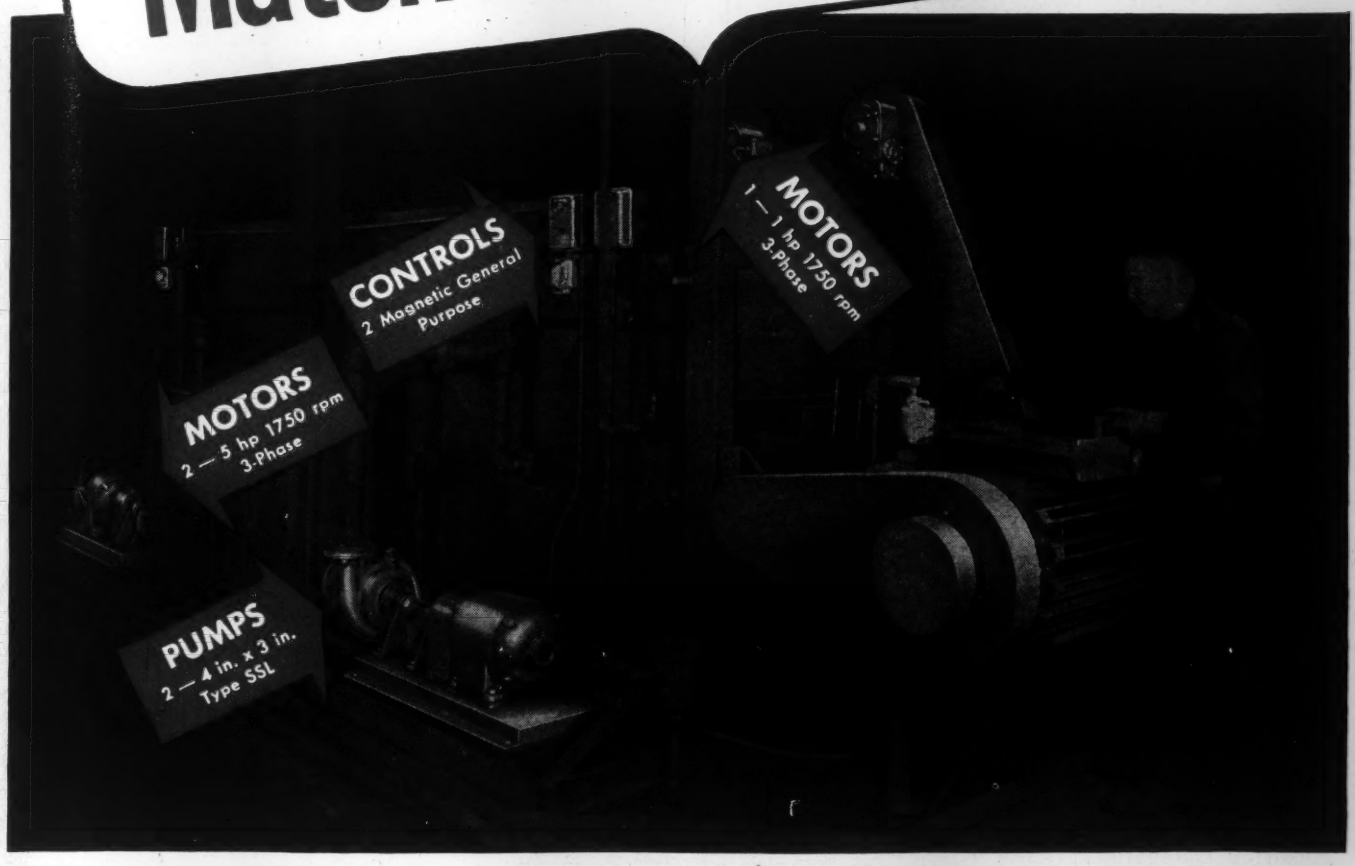
Current & Temperature Relays

Type D-3 relay protects d-c circuits against overcurrent, undercurrent and reverse current. Operating voltage is supplied by a shunt in series with the protected line; moving coil is in parallel with the shunt so it will receive current proportional to the current flowing in the protected line.

Type DT-3 relay protects transformers and a-c or d-c motors and gen-



Matched Components



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LOOK AT THESE modern components . . . a total of 7 . . . motors, controls, pumps . . . all Allis-Chalmers . . . all on one machine . . . all backed by the *same* manufacturer to give you *complete unit* responsibility!

This *Niagara* alkali wash and rinse unit is manufactured by G. S. Blakeslee & Company of Chicago, Ill. It handles trays up to 24 inches by 30 inches at conveyor speeds of two feet per minute. An Eastern plant is saving more than $3000 per year with this unit based on maintenance and down time over the obsolete model it replaced.

Savings like these are in part made possible through the selection of *dependable, coordinated* components . . . backed by a *single* responsibility for their performance. They offer a team that provides protection against unnecessary down time, maintenance and prolonged repair.

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Over 80 Allis-Chalmers Certified Service Shops are located in all major industrial areas. This means your customers can get fast, factory approved service no matter where they are located. It's the kind of service they *demand* . . . and *get* when you incorporate Allis-Chalmers components.

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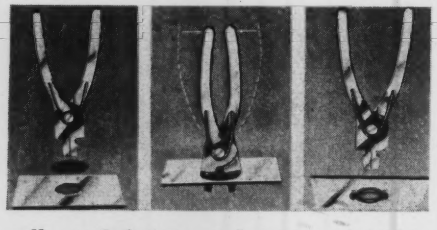
erators from abnormally high temperatures. An exploring coil in the windings of the protected apparatus forms one leg of a resistance bridge that supplies the operating energy for the relay.

Both relays have single-pole double-throw contacts. A permanent magnet core within the moving coil of the relay supplies a constant magnetic field and cuts the size of the relay approximately in half in comparison to its predecessor, D-2. Manufacturer: Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

For more information circle MD 25, Page 181

Insulated Grommet

Designed for insulating blanked holes in metal, Sta-Put grommets prevent cutting, chafing, shorting or rattling of wires, cables, conduit, tubing and pipe passing through such holes. An expanding-type hand tool

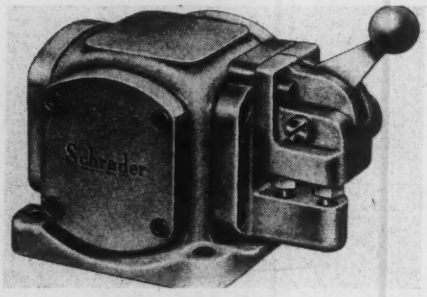


rolls and forces curled prongs tightly against under surface to insure permanent installation. Formed of steel and insulated with neoprene, grommets are available in six sizes with 5/16 to 1-in. holes. Manufacturer: Automotive Rubber Co., 8601 Epworth Blvd., Detroit 4, Mich.

For more information circle MD 26, Page 181

Air Control Valve

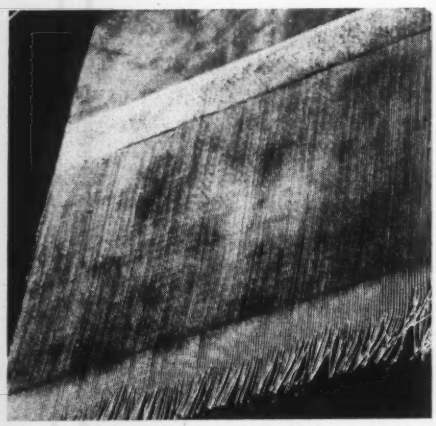
Designed for unrestricted air passage of 250 cfm at 100-psi line pressure, this four-way ½-in. air control valve is base mounted and has manifold pipe ports for concealment of piping. Actuating means is a sliding-seal valve; main body has diaphragm-sealing action. Manufacturer: Scovill Mfg. Co., A. Schrader's Son Div., 470 Vanderbilt Ave., Brooklyn 17, N. Y.



For more information circle MD 27, Page 181

Nonstretching Leather Belt

Reinforced with synthetic cords placed between leather plies, Cordan flat leather belt has a "controlled stretch" feature which prevents per-

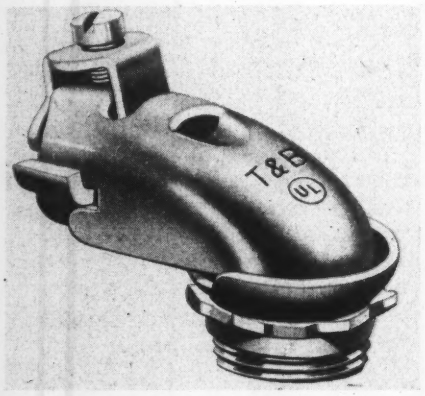


manent elongation under load and thereby eliminates slipping. The belting is available in widths up to 24 in., either endless or with laps prepared or for installation with Clipper belt hooks. Manufacturer: S. R. Sikes Co., Dept. MD, 1028 S. Third St., Minneapolis 15, Minn.

For more information circle MD 28, Page 181

Electrical Connector

For armored cable in sizes 14-2 and 3 through 10-2, and for ⅜-in. flexible conduit, this all-steel No. 321, 90-degree ⅜-in. angle connector fits easily

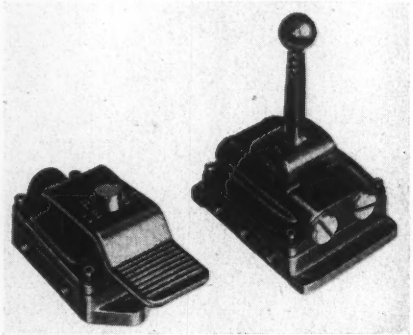


into boxes. Case-hardened locknut bites into box for positive ground and will not loosen under vibration. Tite-Bite clip employs single screw to lock cable. Smooth connector bushing protects insulation on type T or TW wire. Connector is Underwriters' Laboratories listed. Manufacturer: Thomas & Betts Co., Elizabeth 1, N. J.

For more information circle MD 29, Page 181

Air Cylinder Control

Available in three and four-way models with ¼ and ⅜-in. pipe sizes, 880 series valves afford quick, positive control of small air cylinder operation. They can be supplied with vertical and horizontal handle—both with or without spring return —

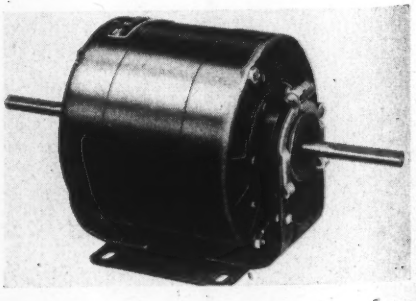


double-treadle foot lever or single-treadle foot lever with spring return. Flexibility of use is provided by interchangeability of parts and use of bases with bottom or side ports which are separate for manifold mounting. Level seat is standard; nonlevel, optional. Two or three-position locking, nonlocking or combination arrangement can be supplied. Manufacturer: Ross Operating Valve Co., 120 E. Golden Gate Ave., Detroit 3, Mich.

For more information circle MD 30, Page 181

Shaded-Pole Motor

Of the shaded six-pole type, this Space Saver fractional-horsepower motor features a 15/16-in. stack as compared with the 1½-in. stack of standard equivalent motors. The motor can be obtained in ratings of 1/15,



"Catsup ON YOUR ICE CREAM?"

Just because you used catsup on your steak, the waiter shouldn't assume you use it on the rest of your dinner too!

And just because one bearing is best lubricated by one particular grade of oil, you shouldn't assume that the same oil is best for *all* bearings on that machine. In many cases it isn't.

OIL CUPS permit you to lubricate each bearing with the oil best suited to that bearing—thus prolonging bearing life, reducing maintenance costs, cutting down-time, boosting production. And oil cups fortunately *cost very little.*

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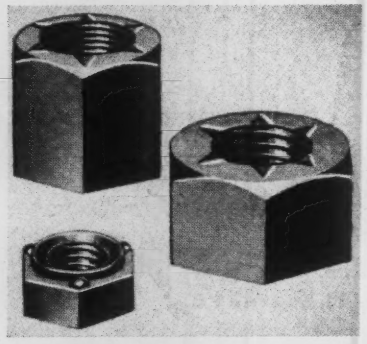
1/20, 1/25, and 1/30-hp with a no load speed of 1150 rpm and a full load speed of 1000 rpm. Manufacturer: Fasco Industries Inc., Rochester 2, N. Y.

For more information circle MD 31, Page 181

Self-Locking Nut

Improved design of Gripco lock nuts utilizes six "double triangle" thread deflection areas instead of the previous three to increase holding

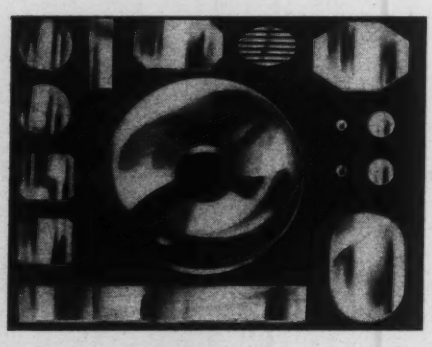


power nearly 50 per cent and thus provide ample grip to withstand severe vibration and strain. Shape of the projections on the weld nuts has been changed so as to give firm, uniform metal-to-metal contact during application of welding current. Thin and Hi nuts are made as well as all standard sizes. Many types are furnished in stainless steel and nonferrous metals. Manufacturer: Grip Nut Co., 310-W S. Michigan Ave., Chicago 4, Ill.

For more information circle MD 32, Page 181

Front-Surface Mirrors

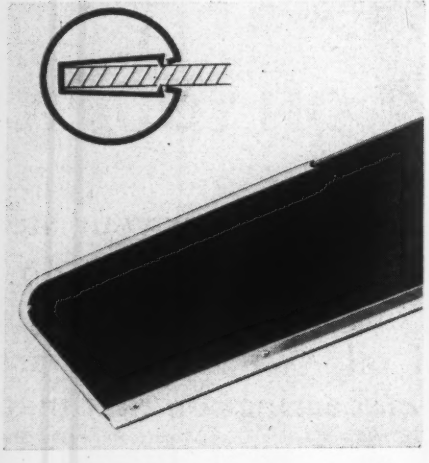
Having a reflectivity of about 93 per cent in the visible spectrum, these front-surface mirrors produced by the Zeno-Kote process can be made to meet any optical or dimensional tolerances. Reflecting surface is produced by thermal evaporation of special aluminum alloy under high vacuum. Deposition of extremely hard but transparent film, which does not affect reflectivity, protects reflecting surface. Suitable for use in precision electronic and optical equipment, mirrors can be dusted or wiped without damage to reflecting surface. Manufacturer: Zenith Optical Laboratory, 123 W. 64th St., New York 23, N. Y.



For more information circle MD 33, Page 181

Snap-On Beading

Raw edges of products of plastic, wood, leather, metal and other materials can be protected and 'dressed up' by application of this stainless snap-on beading. Hand tool is used to apply small toothed clips at intervals along edge. Moulding snaps



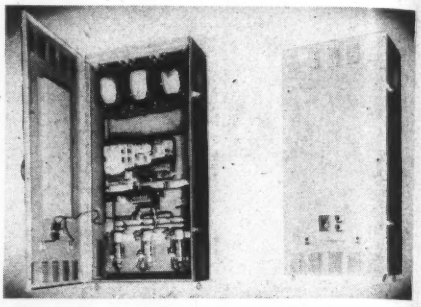
over these clips with permanent gripping action, completely concealing them. Edge can be formed for any shape or size of product. Trim is presently available in ⅜-in. diameter for edges 0.1-in. thick. Manufacturer: Spotrim Corp., 15301 Mack Ave., Detroit 24, Mich.

For more information circle MD 34, Page 181

Electronic Rectifier

Available in wall and floor-mounted styles, these electronic rectifiers are for general-purpose industrial and commercial applications operating on 115/230 or 230/460-v single or three-phase current. Standard units can be supplied with constant or adjustable direct-current output voltages in ratings as high as 230 v, 87 amp. Adjustable-voltage models have range of 60 to 100 per cent of rated output voltage.

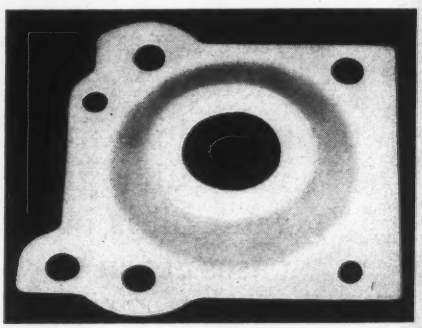
All components, including anode transformers, are mounted in factory assembled enclosures which simplify installation, inspection and maintenance. Manufacturer: Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.



For more information circle MD 35, Page 181

Silicone-Coated Fabric

High tensile strength, impermeability, heat and cold resistance, light weight, flexibility and good dielectric strength are properties of Cohrlastic 3500 silicone rubber-coated Orlon fabric. Diaphragms made from this material have long flex life, can be flat or convoluted, and will operate at temperatures from —75 to 300 F.

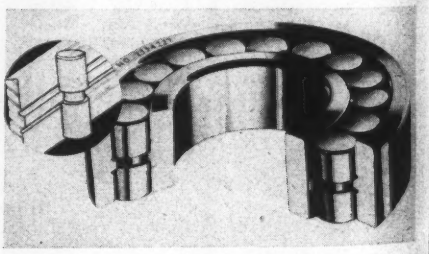


They are particularly applicable where pressure differentials are low and quick response to slight change is desired. Cohrlastic can be supplied either as a fabric 0.01, 0.010 or 0.017-in. thick, or in the form of finished diaphragms as illustrated. Manufacturer: Connecticut Hard Rubber Co., New Haven, Conn.

For more information circle MD 36, Page 181

Cageless Roller Bearing

This Guiderol cageless roller bearing is constructed with tapered guide rail on inside diameter of outer race. Retaining ring is snapped over op-

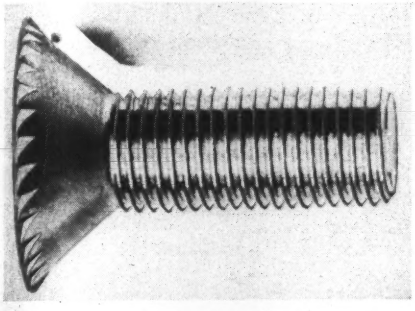


posite side of roller grooves to make assembly self-contained. Rollers are grooved to match guide rail. Right-angle alignment of rollers to their direction of travel is automatically maintained by momentary contact of guide rail and groove when tendency to skew arises. Manufacturer: McGill Mfg. Co., Valparaiso, Ind.

For more information circle MD 37, Page 181

Spin-Lock Screw

Ratchet-like teeth on underside of head fasten Spin-Lock screw securely to surface without washer. Locking power is positive and screw can be hopper-fed. It fastens flush with sur-

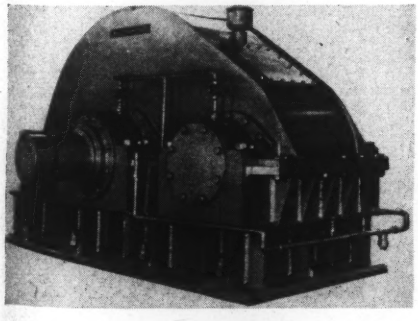


face with no protrusion to catch fingers or clothes. Standard sizes are available with hex, pan, truss or flat head. Manufacturer: Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.

For more information circle MD 38, Page 181

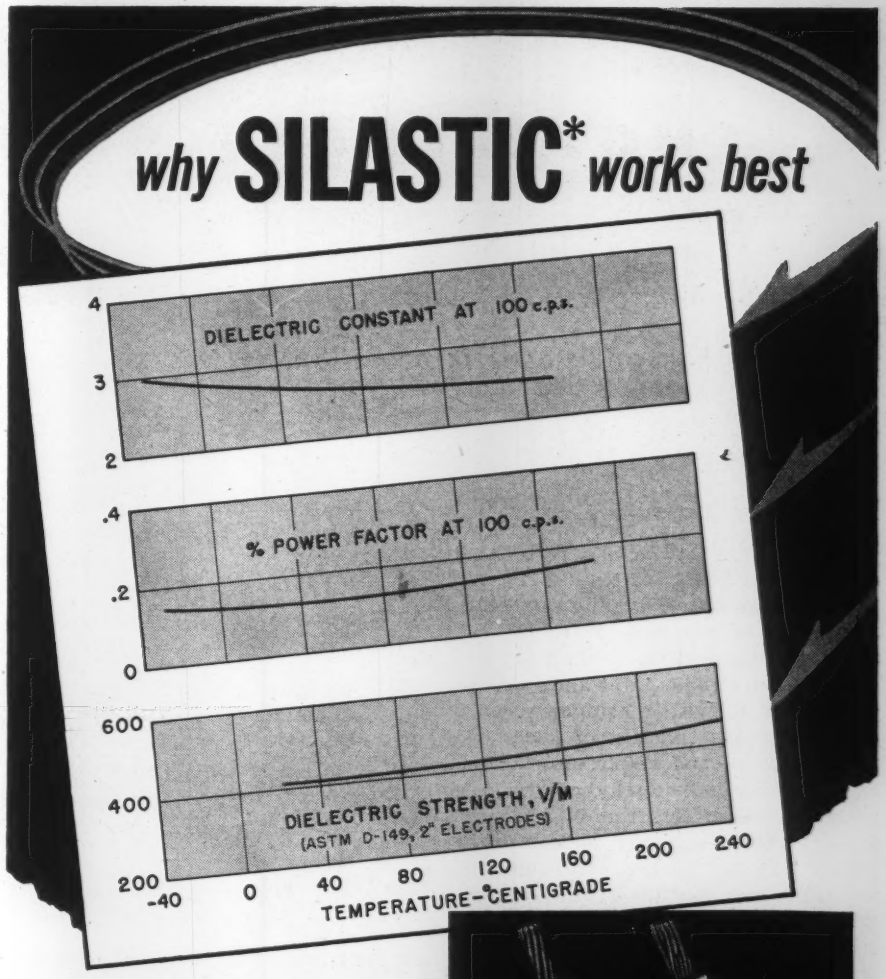
Speed Reducers

These new single and double-reduction industrial speed reducers are available in ratings up to approximately 3000 hp. Gearing is standard AGMA hobbed double-helical. A high



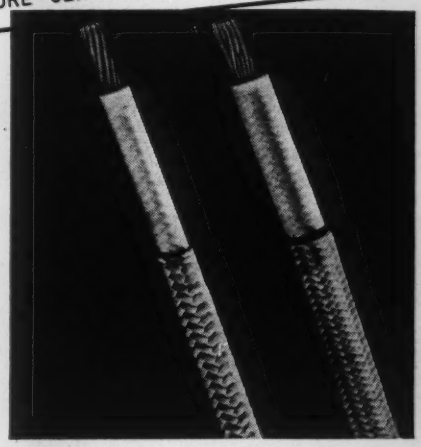
helix angle results in smooth operation, less vibration at higher speeds, and uniform tooth loading and wear. Fabricated steel housings and hardened pinion shafts and gears minimize weight and mounting space. Manufacturer: Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh.

For more information circle MD 39, Page 181



as a dielectric material from −100° to +500°F.

Over that wide temperature span only Silastic, the Dow Corning Silicone Rubber, remains resilient and retains high resistance to weathering, moisture, oxidation and ozone. Add good dielectric properties to those advantages and you have the reasons why Silastic is an excellent insulating material for high temperature, high voltage cable and for use in equipment where mechanical breakdown limits the effectiveness of resinous insulating materials.



Silastic is extruded over wire and cable ranging in size from No. 22 to 500,000 circular mils to provide insulation at temperatures from −80° to 400° F.*

Many engineers are familiar with Silastic as a remarkably heat stable and oil resistant rubberlike gasketing and sealing material for use between −100 to 500° F. Silastic as a dielectric for ignition and intercommunication cable and for field and armature coils is, however, a relatively new development. That's why Dow Corning has made available reprints of a recent article giving the most up-to-date information on the physical, chemical and dielectric properties of Silastic. To receive your copy, phone the nearest branch office or write for Reprint No. P-21.

*T.M. REG. U.S. PAT. OFF.

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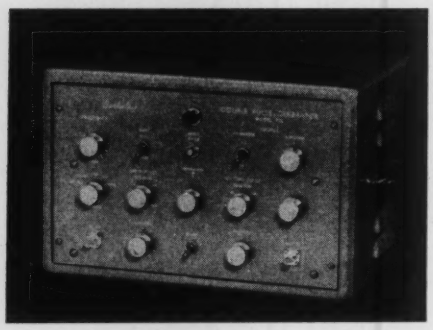
ENGINEERING DEPARTMENT

EQUIPMENT

For additional information on this new equipment see Page 181

Double-Pulse Generator

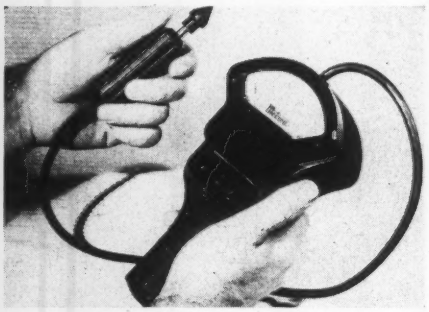
Model 902 generator is a basic laboratory instrument for testing resolution of high-speed scaling circuits, simulation of response of radiation-measurement devices, evaluating response of electronic gates and switches, testing television equipment and checking characteristics of such devices as wide-band amplifiers. Pulse amplitude is individually adjustable, without cross effect, from 0 to 50 and 0 to −200 v. Amplitude of both pulses can be varied after mixing by means of a continuous fine control and a 10-to-1 step attenuator. Pulse rise time is 0.05-microseconds; duration is individually adjustable from 0.15 to 1.5 microseconds. Spacing between the two pulses is continuously variable in two ranges: −0.5 to 3 microseconds. Repetition rate is adjustable in ranges of 1 to 10, 10 to 100 and 100 to 1000 cycles, and can be externally triggered. Output impedance is approximately 400 ohms. Overall accuracy of control calibrations is plus or minus 5 per cent over entire range. Manufacturer: Berkley Scientific Co., Richmond, Calif.



For more information circle MD 40, Page 181

Electric Hand Tachometer

Speeds encountered in motor and generator testing, process control and maintenance work can be measured by type 25D hand tachometer. Ranges of 100-1000, 200-2000, and 500-5000 rpm and fpm, and 10-100, 20-200 and 50-500 fpm are available. Range extending adapters can be obtained to measure speeds as low as 20 rpm and as high as 50,000 rpm. Features include self-calibrating check circuit, quick response and low operating torque. Unit is undamaged by overspeeding or selection of wrong range. It is supplied in carrying case complete with accessory tips, extension, feet-per-minute disks and instructions. Manufacturer: Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.



For more information circle MD 41, Page 181

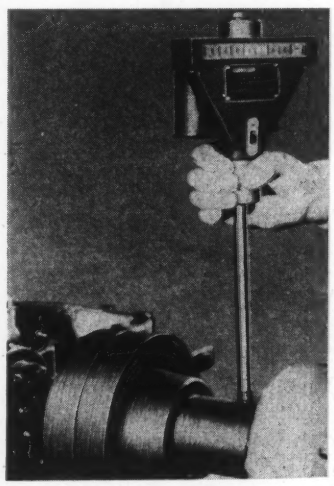
Oscilloscope Tracer

Cathode ray patterns of a repetitive nature can be traced directly on graph paper by means of the Oscilloscope-Tracer, an optical superpositioning device. Projected pattern is exact size of original trace. Double-coated lens with high-reflection upper surface and high-transmission lower surface will not cause parallax. Arm carrying lens is adjustable in length to fit any standard oscilloscope. Operator sees reflection of cathode-ray trace superimposed on paper directly below lens. Small lamp in base of device provides illumination for tracing. Manufacturer: Robert A. Walters Inc., Dept. MD, 4 Gordon St., Waltham 54, Mass.

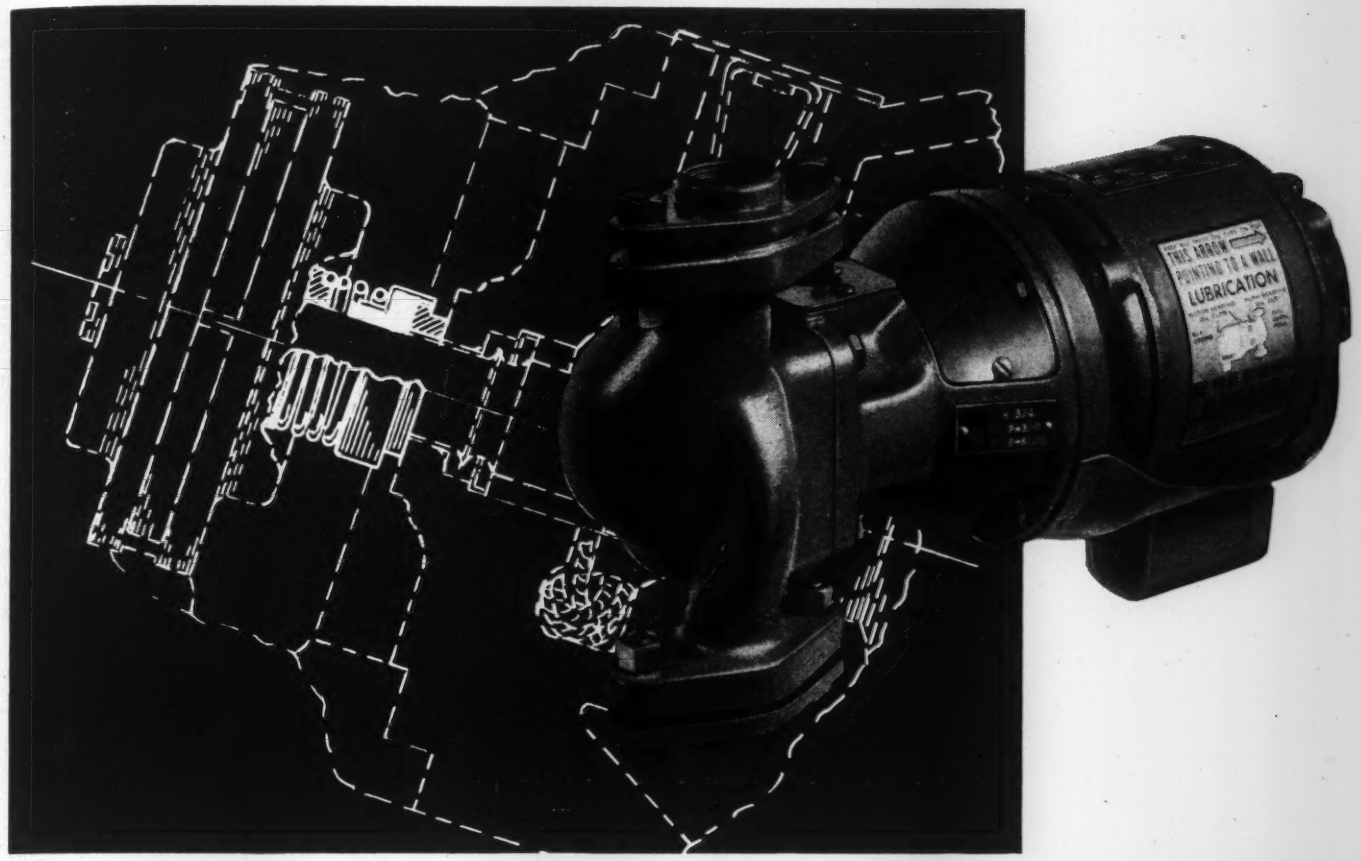
For more information circle MD 42, Page 181

Vibration Tester

Powered by self-contained flashlight batteries, Model P Davey Vibrometer can measure amplitude of machine vibrations. Held in hands against machine to be tested, instrument indicates vibration amplitude by width of oscillation of light beam on graduated ground glass scale. Two models are available which magnify vibratory motion either 125 or 250 times. Detachable 8-in. long probe is furnished for measuring directly on surface of rotating shaft. Probe is housed in tube and runs in ball bearings. Manufacturer: Vibroscope Co., 6 E. 39th St., New York 16, N. Y.



For more information circle MD 43, Page 181

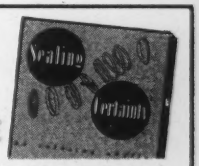


Hydro-Flo Booster Pumps assure *Certainty* in *Sealing* with ROTARY SEALS

Booster pumps must be in a condition to function efficiently at all times—frequent "time out" for repairs or adjustment would destroy most of their usefulness. That's why Bell & Gosset Company, Morton Grove, Illinois, makes mighty certain that component parts are the best they can get—and why, for many years, ROTARY SEALS have been their choice for *assuring* Certainty in Shaft Sealing on the various units in their well-known line of pumps.

This particular adaptation of the time-tested ROTARY SEAL principle was specially engineered to give top efficiency in conjunction with other elements in the Hydro-Flo design. Similarly, "tailor-made" applications have been worked out by our shaft-sealing specialists for equipment in many diverse fields, wherever Certainty in Shaft Sealing is essential for continuous satisfactory performance. ROTARY SEAL can help with *your* problem, too. Call us in at the drawing-board stage for best results—our broad experience can often suggest the simplest design approach from the shaft sealing standpoint.

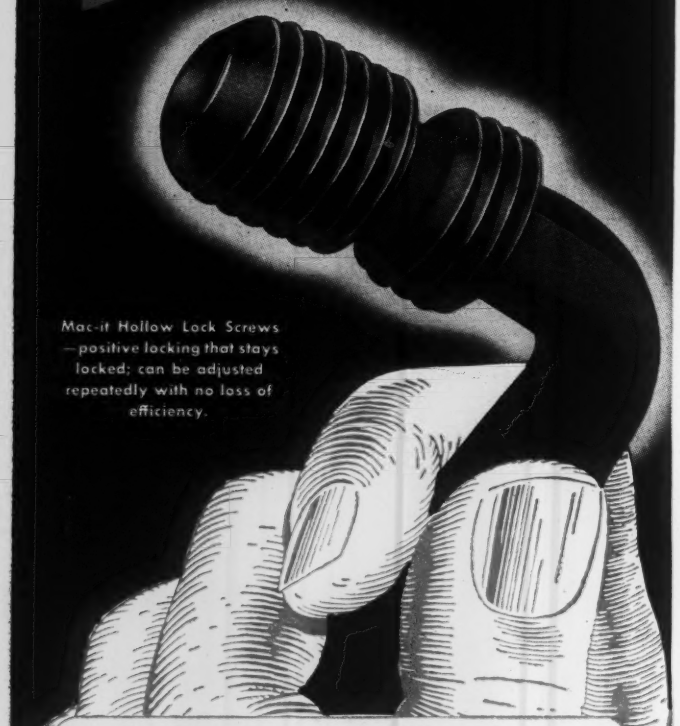
THE ROTARY SEAL PRINCIPLE



is the original approach to a practical solution of a universally troublesome problem. Our booklet "SEALING WITH CERTAINTY" explains and illustrates the principle. We're glad to send it to you without obligation.

THE ROTARY SEAL COMPANY
mechanical seals for rotating shafts

IT'S A
Mac-it ®
PRONOUNCED "MACK-IT"



Mac-it Hollow Lock Screws —positive locking that stays locked; can be adjusted repeatedly with no loss of efficiency.

BETTER, FASTER SERVICE WITH THIS *COMPLETE* MAC-IT LINE!

Because many standard types of Mac-its are stocked throughout the country for quick delivery, and because specials can be engineered to your own specifications, you'll find it pays to investigate Mac-its *first.*

Mac-it's 35 years' experience in the manufacture of heat-treated, alloy steel screws is your assurance of precision, uniformity and strength. Sold through leading industrial distributors from coast to coast and in Canada. Write for new catalog today!

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. . . and many others

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STRONG, CARLISLE & HAMMOND COMPANY
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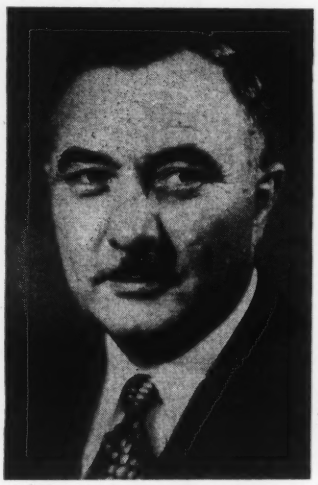
Manufactured by MAC-IT PARTS COMPANY, Lancaster, Pa.

MEN OF MACHINES

Chicago Screw Company announces the appointment of **Carl Voorhies** as chief engineer of the Valve Tappet Division. He will supervise the activities of a fully equipped laboratory for customer service in the solution of valve lifter and valve gear problems, in addition to research and experimental work on hydraulic valve tappets for use in new type high-compression overhead valve engines. Mr. Voorhies spent two years as consultant to several automotive manufacturers, and he has played an active part in the development and perfecting of hydraulic valve lifters and the technique for valve motion studies. He is the author of a number of articles and technical papers on valve tappets and valve gear.



Carl Voorhies

Harold C. R. Carlson

Harold C. R. Carlson, head of the Carlson Co., design consultants, has been elected chairman of the New York District Council, American Society of Testing Materials. Mr. Carlson is well known in engineering circles, was the founder and first president of the Technical Societies Council of New York and is active in the ASME Machine Design division. He has had many technical papers published covering the metallurgy of spring steels and nonferrous alloys, hydrogen embrittlement, stress analysis, etc., and is the author of the Spring Design section of the new Tool Engineers Handbook.

♦

Clarence A. Sherman has been appointed chief engineer of the Warner Division of the Clinton Machine Co. Before joining the Warner Division, Mr. Sher-

From your designs we'll furnish a precision replica in bronze, in standard or special alloy, including helical cuts, chamfers, recesses or tapers. We have excellent facilities for producing a wide variety of simple or complex sizes and shapes in any quantity for many applications, including aircraft, marine, tanks and other military equipment. Laboratory control and inspection methods hold rigidly to your specifications. Research and engineering consultation service is available without obligation. Our seven manufacturing plants also produce a complete line of silent sleeve bearings in many combinations of size, design and materials for a multitude of applications.

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FEDERAL-MOGUL

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RAW MATERIAL

The custom molder has long since resigned himself to his allotted position in the plastics industry, tucked cosily behind the eight ball. It does have the doubtful advantage of being shady there. This will not stop him from letting out with occasional cries of pain when someone rolls the aforesaid eight ball over on his toes without warning. He doesn't like to be disturbed at his efforts to make a meal from the incautious items which flit in his direction.

The ebb and flow of plastics raw materials are a matter of real concern to him. At times this concern rises to wonderment.

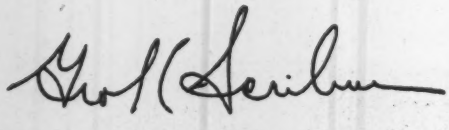
Case history No. 1—Phenolics. . .During the war, many molders had to shift their sources of supply from the accustomed channels. After the war, phenolics were scarce and went on allotment. Some makers set the allotment on pre-war purchases, some on war purchases. Result—headaches for the unlucky ones.

Case history No. 2—Polyethylene. . .This was the darling of radar. When wifely intuition proved scientifically accurate in plotting the whereabouts of her wandering spouse, it was discovered that the demand for this plastic was non-existent. So the R.M.M. (Raw Material Makers) called on the molders to find uses. That takes time, so the R.M.M. were probing too. Result—1948, supply plentiful; 1949, on allocation; 1950 (first quarter), supply plentiful; 1950 (second quarter), on allocation.

Case history No. 3—Polystyrene. . . .This one really speeds up the confusion. January 1950, overnight delivery; April 1950, pending price war; May 1950, perhaps 60 days.

All the poor custom molder has to do is convince his customers that they should order molded parts three months ahead and that their competitors are, to put it mildly, exaggerating if they claim to have an inside track and can get material any time they order it.

We are used to our position relative to the aforesaid eight ball, but we get confused when someone pushes it over on us without fair warning.



George K. Scribner, President

Boonton Molding Co., Boonton, N. J.

Advertisement

man was in charge of the development and design of aircraft hydraulic valves and systems for Vickers Inc., where he worked for the past nine years.

♦

General Electric Corp. has announced the appointment of **Thorn L. Mayes** as manager of the Lynn Motor Engineering Division. Mr. Mayes will have full responsibility for the engineering of all motors manufactured at the company's Lynn, Mass. works.

♦

Leonard J. Maguire has been appointed works manager of the scale plant of Fairbanks, Morse & Co. In 1948 Mr. Maguire was made chief engineer, which position he has held until his recent advancement.

♦

Paul Maurer has been appointed vice-president of National Pneumatic Co. Inc., Boston, Mass.

♦

Charles H. Colvin has been elected executive vice president of the G. M. Giannini & Co. Inc. Mr. Colvin will be in charge of all company manufacturing and engineering activities. Mr. Colvin was founder of the Pioneer Instrument Co. and was formerly associated with Kollsman Instrument Co.

♦

Glenn Baumhardt has been named vice-president in charge of engineering for Redmond Co. Inc. Mr. Baumhardt joined the Redmond Company in 1940. From 1943 to 1948 he was sales manager. He advances to his new position from vice-president in charge of sales-engineering, a liaison activity between the sales and engineering departments.

♦

E. A. DeZubay and **G. W. Hardigg,** engineers of the Westinghouse Electric Corp. have received the Benjamin Garver Lamme scholarships.

♦

J. David Wright has been appointed assistant manager of the General Electric Company's Industry Divisions at Schenectady, N. Y. Mr. Wright will be replaced in his former position as manager of the Industrial Engineering Divisions by **Frederic M. Roberts. Leonid A. Umansky** will assume the post of manager of engineering succeeding Mr. Roberts.

♦

Willys-Overland Motors Inc. announces the appointments of **Miguel Ordorica, George W. Scharbach** and **Harold Klas** to new positions on the engineering staff. Mr. Ordorica has been named special assistant to the chief engineer. Mr. Scharbach succeeds Mr. Ordorica as assistant director of research. Mr. Klas, formerly a designer, has been named a special liaison engineer, working directly under Mr. Ordorica in maintaining engineering department contacts with the National Defense Establishment.

♦

John R. Rhinehart has been named vice president in charge of engineering and development for the Belco Industrial Equipment Division of the Bogue Electric Co.

Reprints from this or other Logbook pages are available for your files. Request them from our Redwood City, California office

How careful design solves difficult sealing problems

Equipment designers who give advance consideration to bearing protection find it pays off in more dependable performance. A good example is the new rocker-arm type shovel which is bringing new economy and efficiency to the costly job of moving earth, heavy ores and other materials. Since the equipment operates in tough abrasive conditions, bearing protection was a major design problem.

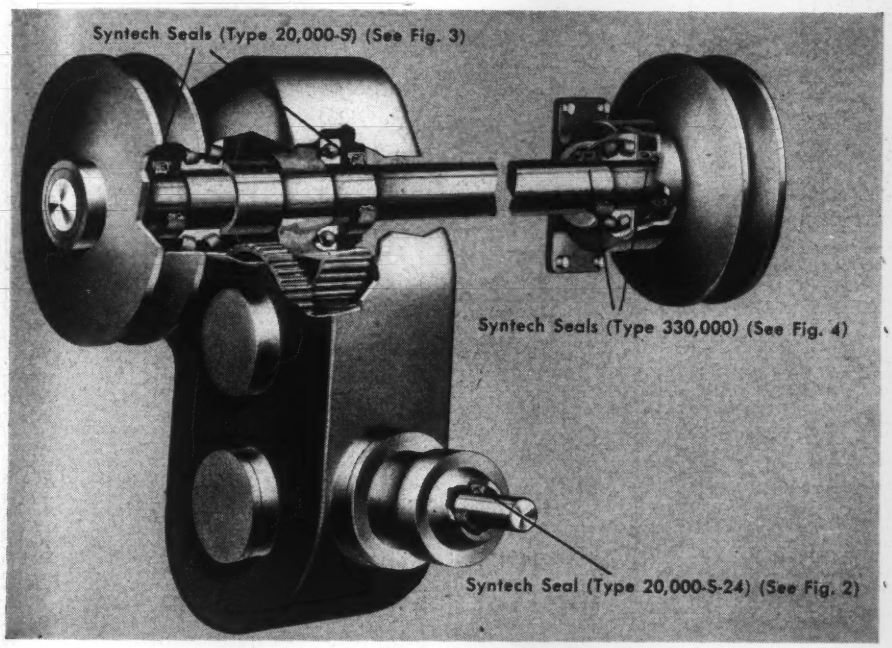


FIGURE 1—Typical transmission from rocker-arm type shovel

A variety of sealing problems encountered

The power transmission (Fig. 1) operates intermittently clockwise and counter clockwise at four cycles per minute. Speeds vary from a maximum of 1500 r.p.m. at the power intake to 60 r.p.m. at the main shaft. Three distinct conditions are presented: flooded lubrication at the power intake, splash lubrication at main bearings and grease pack in the pillow block. Thus three sealing problems are encountered all of which are affected by the reciprocating action of the mechanism. Furthermore, since five seals are required, power absorption is a factor.

Three types National Syntech* oil seals are utilized

The inherent characteristics of National Syntech Seals make them ideal for this application. They are designed for minimum shaft contact, hence create very low drag. At the same time, they are capable of "zero-leakage" under flooded conditions. A spring-tensioned Syntech seal with a leather auxiliary member mounted in opposed position (Type 20,000-S-24) (Fig. 2) is used for the power intake shaft, where extraneous *dust* conditions exist. Two dual-lip Syntech Seals (Type 20,000-S) (Fig. 3) are employed at the upper main bearings where heavy abrasive materials must be withheld and a light lubricant retained.

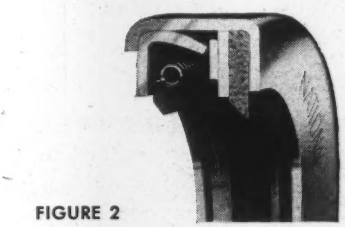


FIGURE 2

At the pillow block, which is subjected to the heaviest abrasive exposure, an unusual expedient was adopted. Two dual-lip Syntech Seals (Type 330,000) (Fig. 4) with lips mounted in tandem are installed with the lips facing *outward*. This installation provides maximum protection from heavy extraneous abrasives and permits cleaning the bearings and seals by forcing heavy grease through from the inside with a grease gun during regular lubricating periods.

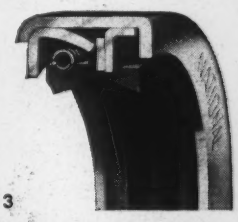


FIGURE 3

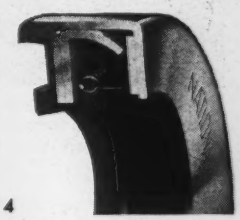


FIGURE 4

National Oil Seal engineers' experience with every conceivable kind of oil or fluid retention problem is yours for the asking. The chances are good that the seal you need has already been developed, in which case you'll save much in tooling costs. However, if special designs are necessary we are ready to help you.

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DETROIT, MICH.	*Room 1026 Fisher Building, Trinity 1-6363*
DOWNEY (Los Angeles Co.), CALIF.	*11634 Patten Rd., Topaz 2-8166*
KANSAS CITY, MO.	*5314 East 12th, Westport 8111*
MILWAUKEE, WIS.	*647 West Virginia St., Marquette 8-8986*
NEW YORK CITY, N. Y.	*122 East 42nd Street, Lexington 2-8260*
PHILADELPHIA, PA.	*401 North Broad Street, Bell-Walnut 2-6997*
REDWOOD CITY, CALIF.	*Broadway and National, Emerson 6-3861*
WEST SPRINGFIELD, MASS.	*1025 Elm Street, Springfield 2-1881*
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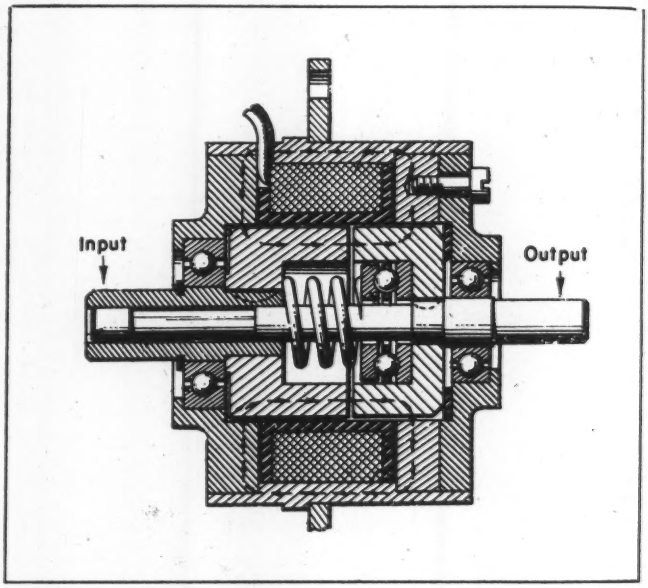
NOTEWORTHY PATENTS

MAGNETIC CLUTCHING MECHANISM employing a stationary winding provides a unit of simple design and small size well suited for computing devices, etc. The coil is attached to the stationary outer housing, surrounding two rotating cups positioned rim-to-rim on the input and output shafts. De-energizing the coil permits the spring-biased right cup to move axially and engage a friction surface on the stationary housing, thus locking the output shaft. Energizing the coil pulls the two cups into contact to couple input and output shafts. The rigid bearing construction employed permits using a small axial cup spacing (0.005-inch, which results in a strong flux concentration between the cup rims and permits use of relatively few ampere turns on the coil. Robert F. Garbarini and Robert S. Edwards have assigned the patent, No. 2,490,044, to The Sperry Corp.



HIGH-SPEED ROTATING PARTS and accompanying reduction gearing for low-speed synchronous clocks or timers are eliminated by a novel electromagnetic device for transforming a-c power into mechanical movement. As covered in patent 2,509,391, granted to William L. Hansen and James M. Hush and assigned to Hansen Manufacturing Co., the device consists of a solid bar armature magnet carrying a crown gear mounted on a vertical column so that the gear can rock about the vertical axis in the manner of a swash plate. Two other magnets, located 90 degrees from the bar magnet, are attached

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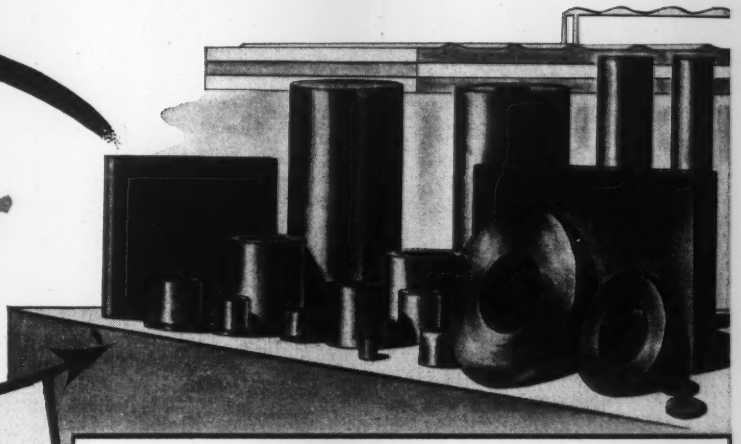

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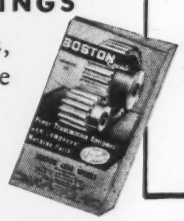

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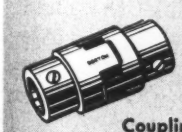
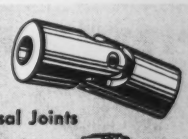
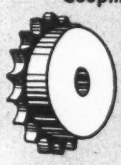
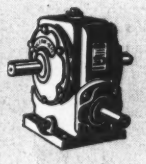

Couplings


Universal Joints


Sprockets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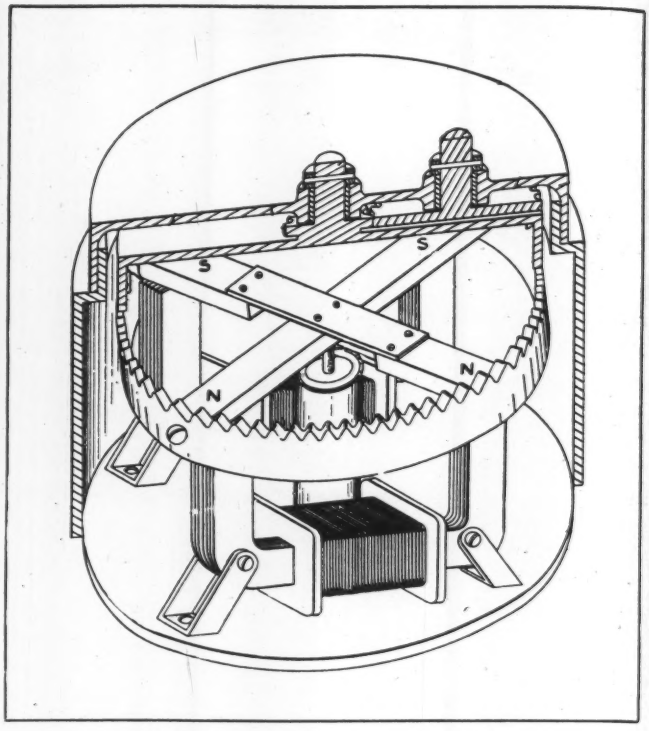
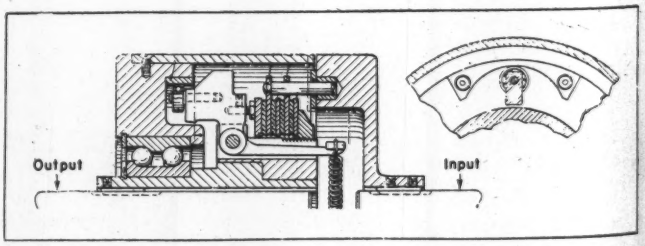


to the latter by a leaf spring. Energizing the magnets causes alternate attraction and repulsion, in a vertical plane, of the armatures. Since the two short magnets are attached to the crown gear indirectly (through the leaf spring and bar magnet) the thrust or tilt imparted to the crown gear by the short magnets lags the thrust from the bar magnet. The combined action of the magnets rocks the crown gear about a second crown gear in the output train. Different numbers of teeth in the two crown gears result in a small advance of the output gear for each current pulsation. Since all parts are relatively slow moving, this design provides negligible bearing wear, decreased noise and longer life. Weights of the moving parts can be made such that the natural frequency corresponds to the current frequency, so that minimum power is required for operation.

CONSTANT ACCELERATION AND DECELERATION independent of the load are characteristics obtained with a new clutch design covered in patent 2,509,061. Overshooting the synchronous speed as well as variation in acceleration because of differences in load are eliminated by the use of flywheel control on conventional friction disks. Assigned to Western Electric Co. Inc. by Arthur L. Holcomb, the clutch utilizes spring-loaded pressure fingers which are over-



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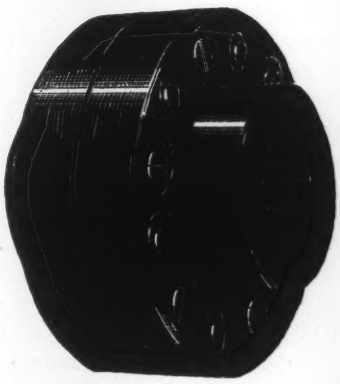
Rubber Bushed FLEXIBLE COUPLINGS



● In plant after plant, maintenance on flexible couplings averages from 10% to 15% of the original cost of the couplings, EXCEPT ON AJAX COUPLINGS.

Maintenance men tell Ajax men that costs on Ajax Couplings have been so close to zero that they don't even consider them. That, together with easy installation and reliable performance, are reasons why more and more plant men are standardizing on Ajax Flexible Couplings.

The performance record of Ajax Couplings with their exclusive rubber bushed bronze bearings extends over 30 years.

There is an Ajax Coupling specialist near you. Consult your phone directory or write us.

AJAX FLEXIBLE COUPLING CO. INC., WESTFIELD, N. Y.

AMERICAN-FORT PITT
Springs

How to be SURE When You Specify Springs

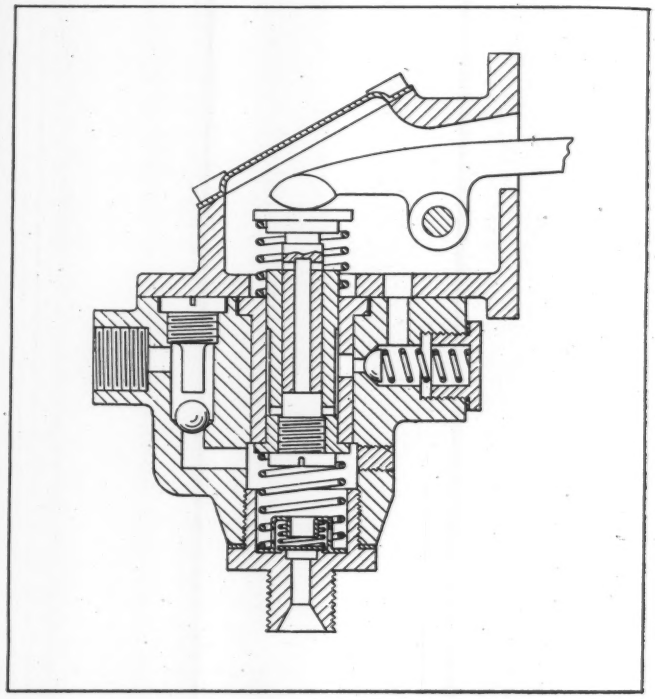
When we recommend a spring for a particular job you can be sure it's a sound recommendation. For many, many years we have specialized in designing springs and wire shapes for almost every conceivable type of application. Whether your requirements call for a standard design or a spring specially created for your product, you can count on us to provide the spring that is precisely right.

Would you like a copy of American-Fort Pitt's 28 page handbook of engineering data on springs? It's packed with facts and formulas—and it's yours for the asking.

AMERICAN-FORT PITT
Spring Division
H. K. PORTER COMPANY, Inc.
McKees Rocks, Pennsylvania

ridden by cams in the free flywheel of the assembly. Inertia of the flywheel thus opposes any sudden changes in transmitted acceleration by causing the fingers to release the normal spring pressure on the friction disks. Action is the same for either direction of rotation and for either acceleration or deceleration.

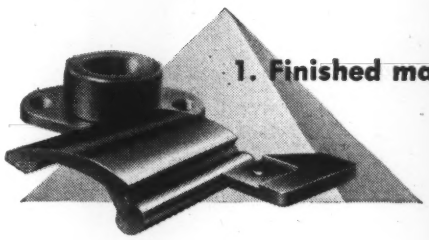
HYDRAULIC SEALING prevents fuel leakage past the piston of reciprocating fuel pumps for internal combustion engines. The pump, covered in patent 2,506,235 granted to Wilfrid E. W. Nicolls and assigned to C. A. V. Ltd., London, England, uses a mechanically driven hollow auxiliary plunger carried



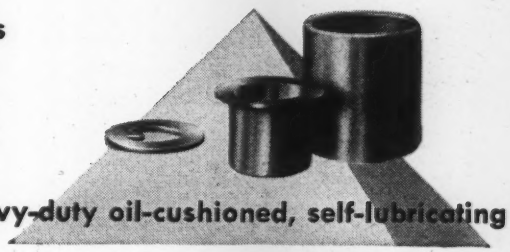
within the main piston. Before the start of each stroke, oil from a reservoir enters the inner plunger and then fills a groove or relieved section between the outer piston and its sleeve. Forcing the inner plunger down traps oil between it and the outer piston, which in turn forces fuel out through the discharge line. Since the effective area of the inner plunger is less than that of the pumping surface of the outer piston, hydraulic pressure between the two is greater than the fuel discharge pressure, which effectively prevents fuel leakage back past the piston.

HYDRAULIC DASH POTS in an overload release clutch prevent uncoupling under momentary torque overloads. Power from the driving hub or pulley is transmitted to the driven sleeve through spring-backed balls seating in recesses or holes in the sleeve. Continuous overload causes the sleeve to force balls to leave their sockets and travel along spiral grooves to a circumferential idler groove in the sliding output sleeve, thus releasing the drive. The mechanism,

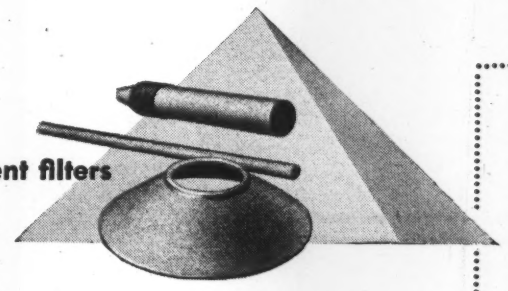
Customers state... Oilite Products yield pyramidal savings...



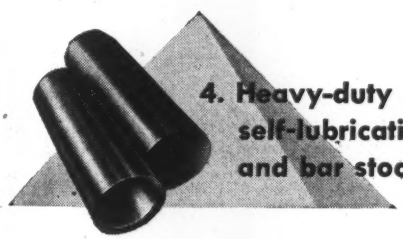
1. Finished machine parts



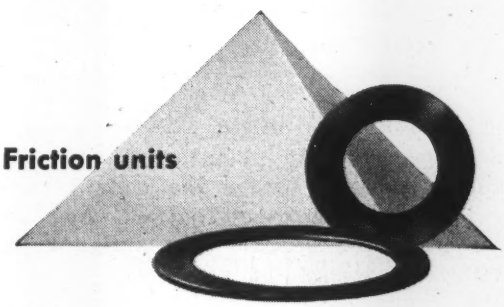
2. Heavy-duty oil-cushioned, self-lubricating bearings



3. Permanent filters



4. Heavy-duty oil-cushioned, self-lubricating cored and bar stock



5. Friction units

Contact your local Oilite field engineer or the home office

SAVINGS in

- Unit Cost
- Assembly Cost
- Capital Investment
- Burden • Floor Space

PLUS

- Quality and Service
- Engineering Insurance

PLUS

(Nationwide and Canada)

- Field Engineers
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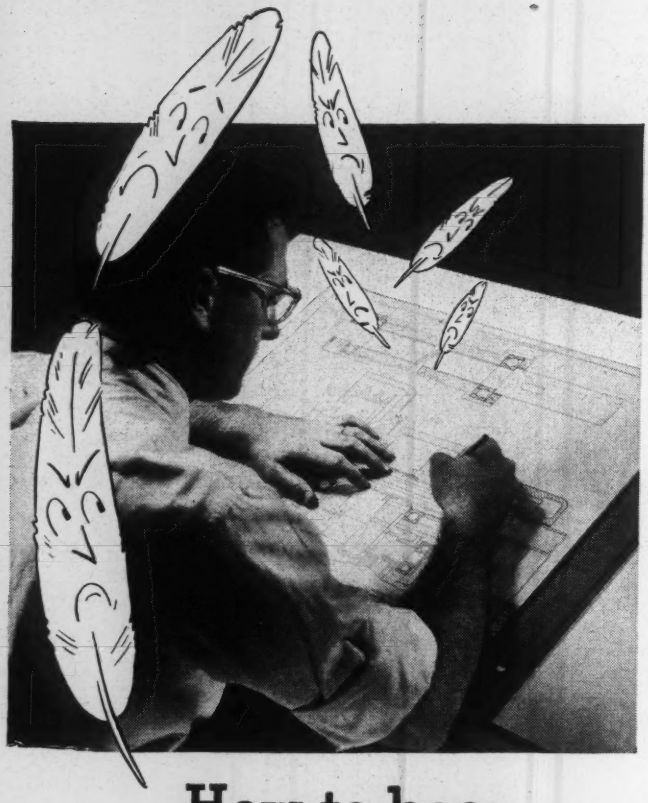
Amplex MANUFACTURING COMPANY

SUBSIDIARY OF CHRYSLER CORPORATION
DETROIT 31, MICHIGAN



How to keep Line "FEATHERS" out of your hair!

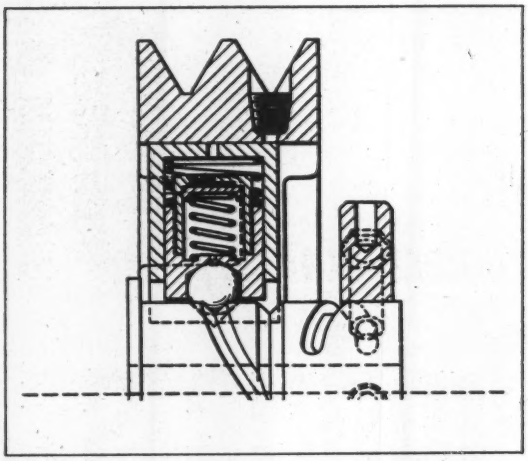
It was a clean, sharp line till it had to be erased. But when it was re-inked, brother how it feathered and "blobbed"!

Feathering lines are one of the things you *don't* have to worry about with Arkwright Tracing Cloth. Even erased surfaces will take a neat, sharp line. What's more, you'll never find pinholes, thick threads or other imperfections in Arkwright cloth. You'll never have to fear that your drawings will discolor, go brittle or become opaque with age. A drawing on Arkwright Tracing Cloth will yield clean, clear blueprints years after you make it.

Aren't your drawings worth this extra protection? Arkwright Finishing Co., Providence, R. I.

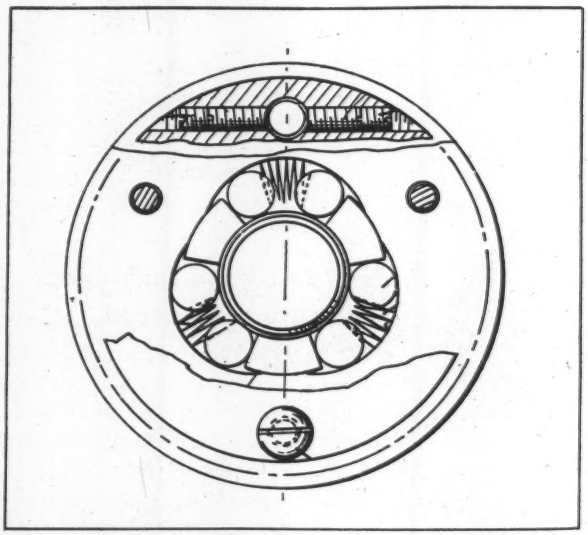
ARKWRIGHT *Tracing Cloth*

AMERICA'S STANDARD FOR OVER 25 YEARS



described in patent 2,508, 061, granted to Earl R. Fish and assigned to Lipe-Rollway Corp., utilizes a dash pot assembly in back of each ball to prevent premature unseating of the balls, permitting uncoupling only when the torque progressively increases above a preset value.

SELF-LOCKING, ONE-WAY-DRIVE coupling covered in patent 2,509,541 provides a positive connection between driving and driven members and is locked against rotation by a torque applied to the output shaft. When torque is applied to the driver, a pin and slot arrangement provides sufficient relative angular rotation between the two halves of the coupling to release a sprag type lock between the coupling and the stationary housing. Torque on the output shaft, however, causes the balls to wedge against the housing to prevent rotation. Aero Supply Manufacturing Co. Inc. has been assigned the patent by Charles R. Suska.



Complete printed copies of all patents are available from the Commissioner of Patents, Washington 25, D. C., for 25 cents each.

We make them as if we were going to use them

Precisely controlled heat treating is just one of the steps taken at Accurate to assure adherence to your specifications.

. . . and it lowers *the overall cost of your springs*

HERE at Accurate we make springs the way we'd like to have them made for us if we were the user. We believe this guarantees you the best possible springs —uniformly RIGHT springs that permit maximum assembly rates and reduce the number of rejects due to faulty operation. It all adds up to lower manufacturing costs and better product performance for you.

Plan now to find out more about Accurate spring service and try Accurate on your next job. ACCURATE SPRING MFG. CO., 3813 W. Lake Street, Chicago 24, Ill.

Ask for your free copy of the new revised Accurate Handbook of Technical Data on Springs. This booklet has been out of print for some time and if you have previously asked for a copy and have not received it, we would appreciate your asking again.

Be sure the springs you buy are Accurate

Accurate Springs

Springs
Wire Forms
Stampings

ARCH SUPPORT
withstands the strains

because the "arch" is stronger

Extra strength to withstand electrical and mechanical strain . . . that's why Ward Leonard's STRIPOHM resistors are made with the broad sides *arched* instead of flat.

This hump-backed shape also gives you (1) more even and uniform winding because the wire *hugs* the core, (2) greater area for heat dissipation. Low mounting brackets and terminal arrangement facilitate multiple stacking.

Write for Bulletin 23. WARD LEONARD ELECTRIC COMPANY, 58 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD
ELECTRIC COMPANY
Result-Engineered Controls
RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

NEWS
OF MANUFACTURERS

Lear Inc. has acquired the balance of 9,600 sq ft of space in its main building in Grand Rapids, Mich., increasing the main plant area to 180,600 sq ft. Under lease to another firm at the time of Lear's purchase of the building, the space will be used to increase Lear production of autopilots, gyros, electromechanical actuators, automatic controls, servomechanisms, aircraft radio and other aircraft accessories.

♦

Stackpole Carbon Co., St. Marys, Pa., has signed a comprehensive working agreement designed to bring the **Allen-Bradley Co.**, Milwaukee, Wis., into the manufacture of Ferrite components molded from powders under license by **Phillips Laboratories Inc.** Based on this agreement, Stackpole will supply to Allen-Bradley all of its technical background, engineering assistance and manufacturing knowledge pertaining to Ferrite production. The agreement is reciprocal as to a cross exchange of information and will continue for a minimum of seven years. Based on a Phillips' license, Stackpole has been producing Ferrite under the tradename Ceramag and will continue to do so; Allen-Bradley will be an additional source of supply.

♦

Sprague Electric Co., North Adams, Mass., and **Philips Industries Inc.**, Hartford, Conn., have formed the **Ferroxcube Corp. of America** with headquarters at 50 East 41st St., New York, N. Y. This new corporation will manufacture Ferroxcube, a ferromagnetic ferrite particularly useful as a core material in high frequency coils and transformers. Ferroxcube was originally developed by the Phillips Research Laboratories in Holland.

♦

Tuttle & Kift Inc., Chicago, Ill., has completed the first step in a plant expansion program which will total $475,000. The first of two new buildings has been completed, and new equipment, including a wholly automatic heating coil loading line, is being installed. Tuttle & Kift, a subsidiary of **Ferro Enamel Corp.**, Cleveland, O., manufactures electric range surface units, oven units, switches, hot water heater units, and a complete line of industrial heating elements.

♦

The **Kaiser Aluminum & Chemical Corp.**, Oakland, Calif., is planning a round of actions designed to pour out multimillions of pounds of aluminum production for defense and industry. Expansions planned are: a 30 per cent increase in reduction capacity which will mean 80 million more pounds of aluminum pig per

year; an increase in finishing capacity of 72 million pounds a year at Kaiser's Trentwood rolling mill, Spokane, Wash.; a step-up of production at the company's bauxite refining plant, Baton Rouge, La., making available up to 160 million pounds additional alumina annually to go into making more aluminum pig; and an array of new products set up for manufacture at the rod, bar, wire, and cable mill, Newark, O. In addition to these definite increases, Kaiser Aluminum has submitted to the Government defense agencies a number of alternate plans to increase aluminum production at least 400 million pounds.

♦

Ford Motor Co. has begun a long-range program of modernization and rehabilitation of its pressed steel operations in the Rouge plant. The program, which will be completed by 1952, is expected to increase production efficiency and improve working conditions. Major improvements will include the installation of new equipment, rearrangement of present equipment, and the construction of two large inter-floor ramps to speed flow of materials. Other changes will involve the improvement of materials handling and warehouse and storage facilities.

♦

On July 1, 1950, **Alloy Precision Castings Co.**, Cleveland, O., assumed through purchase of rights and facilities all precision casting operations that were being performed under the Mercast license by the **National Bronze and Aluminum Foundry Co.** of Cleveland. The new company will continue to operate at the National Bronze location.

♦

Addition of a new mill for the production of electric resistance welded tubing at its Alliance, O., plant has been announced by the **Babcock & Wilcox Tube Co.** The mill, the third such unit for the Welded Tube division, will produce tubing with outside diameters ½-inch and up with wall thicknesses 20 gage and heavier.

♦

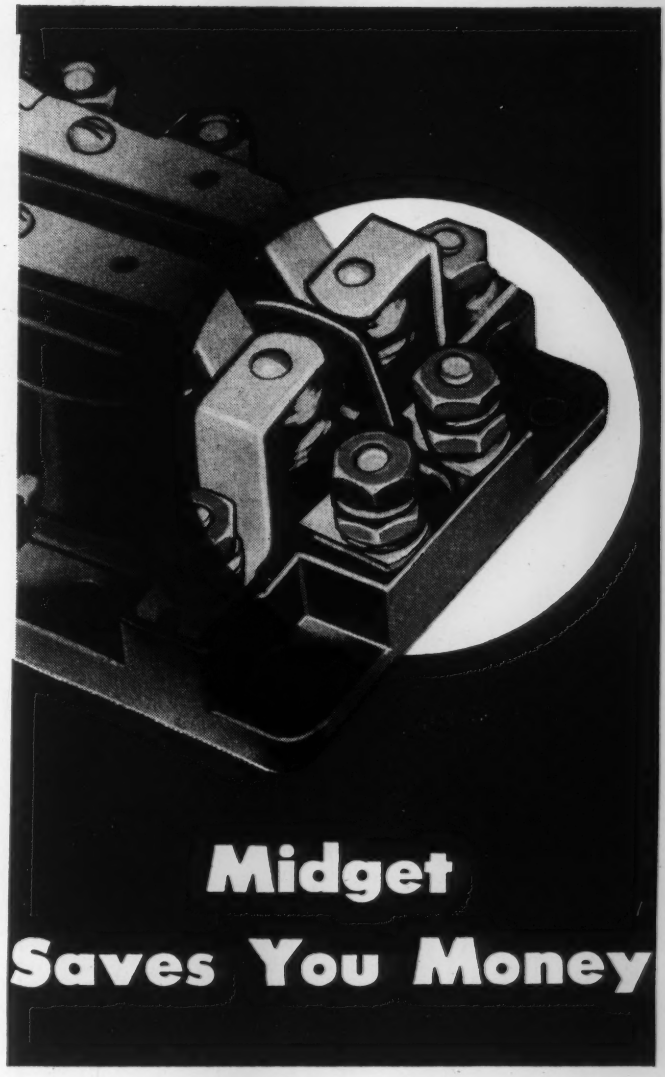
The **Newark Gear Cutting Machinery Co.** has been reorganized as **Newark Gear Inc.** with plant and offices at 69 Prospect St., Newark, N. J. A program of modernization is underway, and additions to the line of gear cutting equipment produced by the company is being planned.

♦

Wheelco Instruments Co., 847 W. Harrison St., Chicago, Ill., manufacturer of industrial electronic control equipment, has acquired the 50 by 120-ft lot adjoining the Wheelco building. The new property will be used for a warehouse.

♦

Dodge Mfg. Corp., Mishawaka, Ind., manufacturer of power transmission machinery, has acquired all of the capital stock of the Chicago Thrift Co., 1555 North Sheffield Ave., Chicago, Ill. Chicago Thrift manufactures small metal and plastic banks, etched metal products such as nameplates, instruction plates, clock and instrument dials, novelties, etc. The com-



because it does man-sized jobs

A mighty midget is this Ward Leonard 105 Relay!

It's frequently used on jobs normally requiring heavier-duty relays. Certain types are Underwriters-approved as motor controls.

Unique spring suspension adds a self-cleaning action to the oversize silver-to-silver contacts. Note how the posts are securely anchored in the base—another typical Ward Leonard feature.

Write for Bulletin 105. WARD LEONARD ELECTRIC CO., 58 South Street, Mt. Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY

Result-Engineered Controls

RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

W L

Extra Strength in this Oilproof Hose!

Resistoflex hose assemblies provide the answer to constant flexing and vibration in hydraulically controlled equipment.

THREE REASONS explain why more and more manufacturers standardize on Resistoflex Hose Assemblies. These lines, containing no metal reinforcements, have: (1) Superior flexibility and are fatigue-proof. (2) High burst strength for medium as well as low pressure installations. (3) Complete impermeability to oils. All these advantages, of course, add up to fewer service troubles and replacements.

The extra durability of Resistoflex hose is assured by its unique construction. It has the compar tube. This high tensile tube not only reinforces the hose against shock loads, but also helps maintain clean systems because it doesn't swell, gum or erode in contact with oils.

If you have an application involving flow of hydraulic, lubricating or water-insoluble cutting oils, it will pay you to learn more about these light, cost-cutting, compar-tubed lines. Other assemblies available for gases, refrigerants or tough solvents. Write us about your problem, or for more information.

Trade-Mark Reg. in U.S. & Can. Pat. Off.

TRADE RESISTOFLEX MARK

RESISTOFLEX
CORPORATION

Belleville 9, New Jersey

SYNTHETIC FLEXIBLE PRODUCTS AND PARTS FOR INDUSTRY

pany also holds a jobbing license for the Chicago territory for anodizing aluminum under the Alumilite process. In 1944, Dodge acquired the Etching Co. of America, Chicago, which also manufactures etched metal products. Dodge plans to bring about a merger of these two subsidiary companies under Illinois law. Upon consummation of the merger, operations will be conducted under the name Chicago Thrift-Etching Corp.

♦

Astron Corp., manufacturer of filters for radio-noise suppression, molded paper tubular capacitors and electroltics, is located in its new plant at 255 Grant Ave., East Newark, N. J.

♦

Completion of a new 11,000-sq ft plant has doubled the production capacity of the **Herman Stone Co.**, Dayton, O., manufacturer of granite surface plates. The new plant features a center drive-through to expedite handling of raw materials and finished products. Large bays on either side accommodate an installation of new production machinery, including overhead cranes and a specially designed lapping machine capable of handling surface plates up to twenty feet in length.

♦

Hy-Pro Tool Co., subsidiary of the **Continental Screw Co.**, is now established in new quarters which adjoin the parent-company plant in New Bedford, Mass. With double the capacity of the former quarters, the new plant will provide facilities for meeting a heavy schedule for production of Hy-Pro products —taps, slotting saws, allied metal cutting tools, insert bits and holders.

♦

The new $27,000,000 high alpha cellulose plant of Columbia Cellulose Co. Ltd., near Prince Rupert, British Columbia, is expected to come into production during the first quarter of 1951. The parent company is the **Celanese Corp. of America.**

♦

Porcelain Metal Products Co., Pittsburgh, Pa., porcelain enamelers, steel fabricators, designers and engineers, has been sold. The new group of owners includes three of the company's present executives and several newcomers who have held executive posts with outside firms.

♦

Caterpillar Tractor Co., Peoria, Ill., has formed a wholly owned British subsidiary, Caterpillar Tractor Co. Ltd. The new company will procure, inspect, store and ship British-made Caterpillar parts to the company's dealers in the United Kingdom and other countries.

♦

Aeroquip Corp., Jackson, Mich., manufacturer of aircraft and industrial flexible hose lines and fittings, is planning a $500,000 expansion program to meet present demands for its products. A plant addition of 55,000 sq ft will provide space for manufacturing activities.

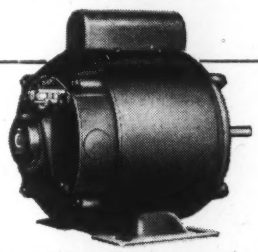
Century 1/8 TO 3/4 H. P. MOTORS

Choose From These Many Types to Fit Your Job

HEAVY-DUTY for Industrial and Appliance Use

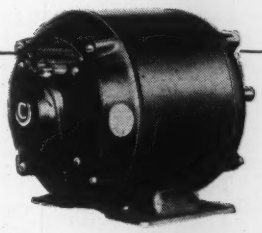
From Century's wide range of types and sizes, there's a proper motor for all popular applications. You can be confident that the right Century motor will assure a long life of satisfactory performance.

Shown here are examples of Century's line of FRACTIONAL HORSEPOWER motors—ruggedly built for smooth, quiet operation, with a remarkable freedom from vibration

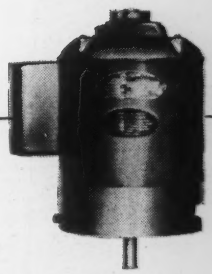


TYPE CSH — Capacitor Start Induction Single Phase Motor suitable where high starting torque and normal starting current is satisfactory.

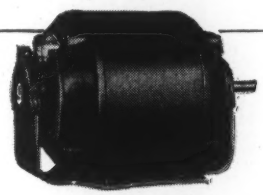
TYPE SP — Split Phase Induction, Rigid Base, Single Phase Motors suitable for light starting duty.



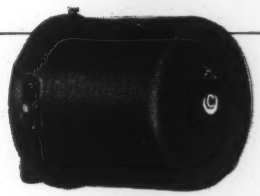
TYPE SC — Squirrel Cage Polyphase Motor built in fractional sizes for all torque requirements.



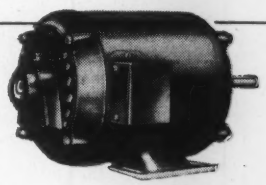
JET PUMP MOTOR—Capacitor Start Single Phase Motor available in sizes for practically every jet pump application.



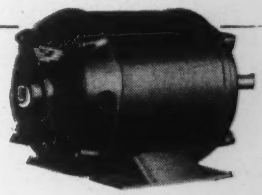
TYPE SP — Split Phase Induction, Cushion Base, for quiet operation.



OIL BURNER MOTOR especially designed for this service. Compact, rugged; smooth, quiet starting and running.



TYPE RS — Repulsion Start Induction Single Phase Brush Lifting Motor suitable for applications requiring high starting torque and low starting current.



TYPE DM — Direct Current built in sizes and ratings for applications where direct current is available or its use desirable.

UNIT HEATER MOTOR provides smooth, quiet performance throughout a long service life.

GEAR MOTOR, compact, rugged, ball bearing equipped, for your high torque, slow speed requirements.

The complete line of Century motors includes a wide range of types and kinds, from 1/8 to 400 horsepower. They are available in open rated, splash proof, totally enclosed fan cooled and explosion proof frames.

Specify Century motors for all your electric power requirements.

CENTURY ELECTRIC CO.
1806 Pine Street
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GOT A RELAY PROBLEM?

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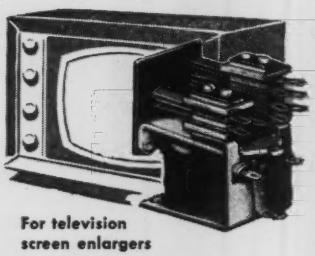
GENERAL PURPOSE RELAYS

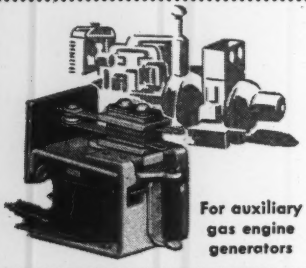
Low in Cost — Small in Size — Dependable in Performance — AC or DC



For television screen enlargers

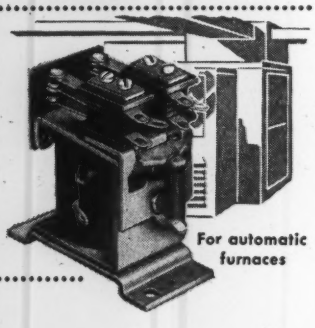
For radio transmitter panels

For industrial smoke detectors

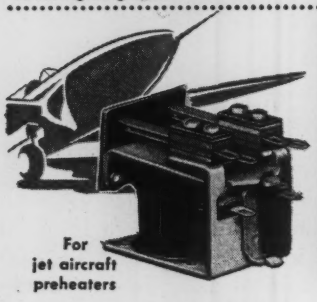


For auxiliary gas engine generators

For photoelectric street lighting control



For automatic furnaces



For jet aircraft preheaters

In addition R-B-M General Purpose Relays are used on X-Ray apparatus, permanent wave machines, wire recorders, automotive radio telephone communication equipment, vending machines, coin operated phonogaphs and many other applications.

What is your relay problem?

Write Dept. B-9 today for Bulletin 570

RBM

R-B-M DIVISION
ESSEX WIRE CORP.
Logansport, Indiana

MANUAL AND MAGNETIC ELECTRIC CONTROLS
—FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

SOCIETY ACTIVITIES

The **National Metal Trades Association** will present its Second Annual Award for outstanding achievement in the field of industrial relations at its 51st Annual Convention to be held September 27-29 in New York.

Selection of the individual to whom the award will be given will be made by a five-man committee headed by Roe S. Clark, vice-president and treasurer, Package Machinery Co. Other members of the committee are: Howard D. Grant, Goodman Mfg. Co.; R. C. Lanphier Jr., Sangamo Electric Co.; Howard B. Spain, The Seagrave Corp.; and G. A. Waters, Wagner Electric Co.

Any American citizen is eligible for the award. The award committee makes its selection from a list of nominations made by members of the Association. Last year's award was made to Louis Ruthenburg, chairman of the board of Servel Inc.

♦

The New York District Council of the **American Society for Testing Materials** has elected the following officers for a term of two years.

Chairman
Harold C. R. Carlson, owner of The Carlson Co.

1st Vice Chairman
George O. Hiers, National Lead Co.

2nd Vice Chairman
S. R. Doner, Raybestos-Manhattan Inc.

Secretary
A. A. Jones, Anaconda Wire and Cable Co.

The ASTM has more than 150 committees working on standards, specifications, testing, research, ordnance, etc., and publishes material specifications and test methods which are used as standard throughout the world.

♦

Gray Iron Founders' Society, Cleveland, O., has established an industry-wide contest to determine the most significant and outstanding examples of where foundry engineers have redesigned a part or component for casting in place of another production process. All members of the gray iron foundry industry have been invited to participate. Suitable awards are being planned for the contributions which are to be judged by the advertising committee of the Society.

♦

A. James Leone, chairman of the Boston chapter of the **American Society of Tool Engineers,** was elected recently to the Executive Board of the **Engineering Societies of New England Inc.,** an organization consisting of 21 member societies with a total membership of 7000 engineers.

WHY ENGINEERS SPECIFY HOUGHTON'S "O" RINGS

Design engineers who continually specify Houghton "O" Rings base their preference on these points: **REASON 1** They can rely on high standards of quality and uniformity, regardless of sizes or quantities needed. **REASON 2** From past experience, engineers realize the dependable sealing and long-range performance factors which mean trouble-free service. **REASON 3** Houghton synthetic rubber "O" Rings, as well as the entire line of Houghton standardized packings, are backed by years of experience and "know-how" plus an engineering service always ready to cooperate on difficult design problems.

If you have a pneumatic or hydraulic packing problem, write or call E. F. HOUGHTON & CO., 303 W. Lehigh Ave., Philadelphia 33, Pa.

HOUGHTON'S VIM LEATHER & VIX-SYN PACKINGS

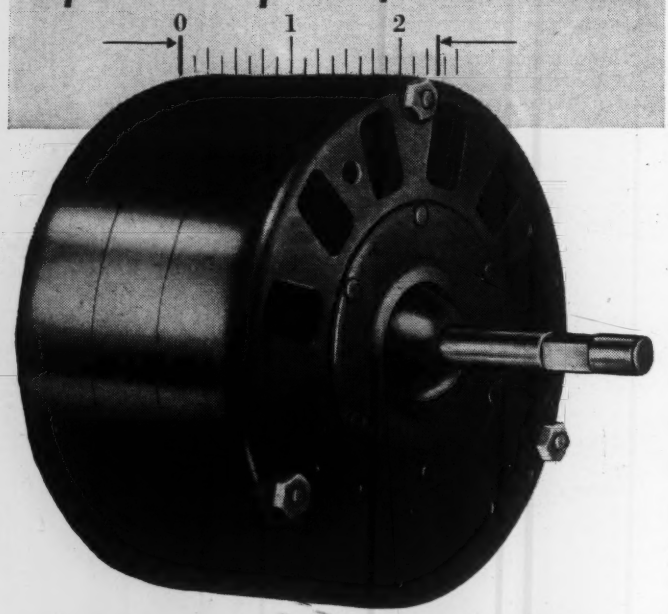
NOW AVAILABLE

in "SPACE-SAVER"
and REVERSIBLE MODELS

FASCO

6-POLE SHADED POLE MOTORS

1/30 THRU 1/8 HP, 1000 RPM



- NEW! FASCO "SPACE-SAVER"... FLAT, COMPACT, POWERFUL
- NEW! FASCO REVERSIBLE... AVAILABLE IN ALL 6-POLE MODELS

★ Quiet, uniform performance at all speeds

★ Speed reductions to 500 RPM

★ Higher efficiency . . . long life

★ Mounts to meet every need . . . interchangeable with other motors

WRITE today for full performance data, dimensions, and applications to FASCO Industries, Inc., 146 Toppin St., Rochester 2, New York.

FASCO
INDUSTRIES, INC.
ROCHESTER 2, NEW YORK

Induction Brazing

(*Concluded from Page* 140)

make the total piece cost per unit $1.74 less for the brazed assembly than for parts made from forgings. With the economy and serviceability confirmed, the brazed method was released for production.

For materials, pearlitic malleable was chosen for the castings because its strength, high modulus, and inherent damping capacity offered a favorable combination of properties for a rigid and quiet gear assembly. Machinability was satisfactory, and in addition it could be easily brazed without any special surface degraphitizing treatment. Steel selected for the drive shaft was SAE 1151 because of the requirements of strength in the cold-drawn condition and good machinability.

The actual assembly operations are, for the most part, conventional. Preformed rings of Easy Flo No. 45 silver solder are first slipped in place on the shaft, and both parts are then alkali cleaned, rinsed and dried. The shaft is dipped in hot (140-150 F) Handy Flux, then pushed in place in the casting. Brazing on one station of a Tocco two-station induction heater requires 72 seconds, *Fig.* 2. The fixture rotates during heating, automatically positions the work in the coil, and controls the entire cycle including retraction ready for unloading. Excess flux is washed off in hot water after brazing and the parts are visually checked for presence of silver solder at the end of the joint. A percentage check with a torsion proof-load is also made for quality control.

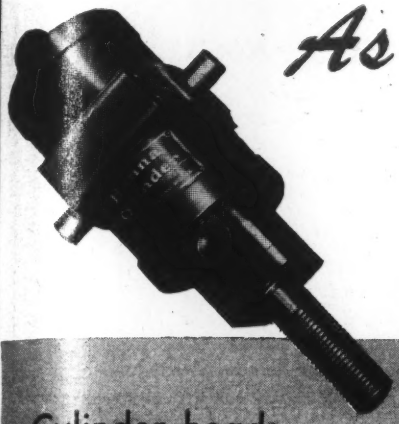
Full use of the operator's time is realized by using the second station of the Tocco machine for a second brazing job, the clutch housing and cylinder sleeve assembly, also for the Ultramatic Transmission. Parts used for this assembly are also shown in *Fig.* 1. A substantial saving was obtained on this part also by a design change permitting the use of induction brazing in preference to older methods.

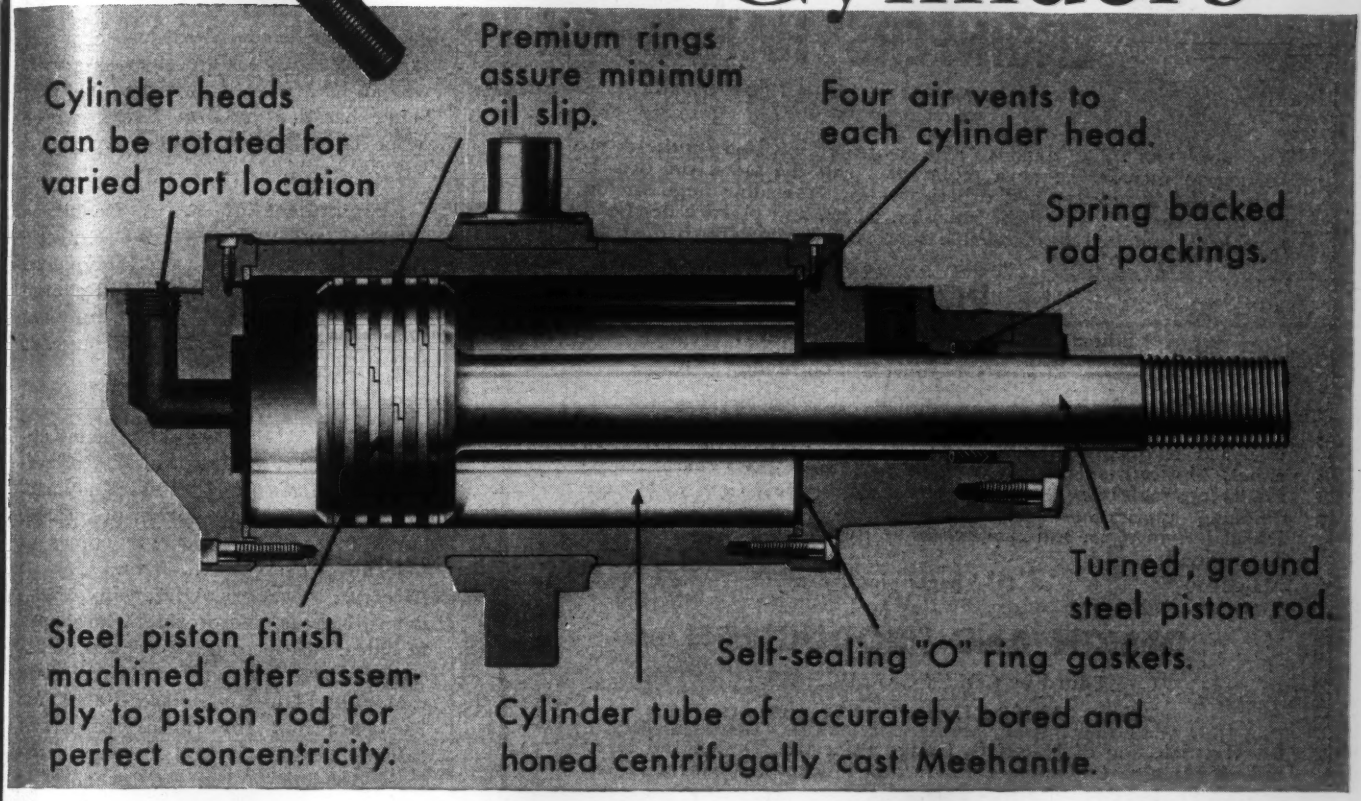
They Say...

"What is it that makes the average citizen go overboard financially in buying a car? Certainly it is not as prosaic a matter as just having transportation. The American motorist has more romantic reasons. It is more like what one economist called a "love affair" between the car and the owner, and who thinks too much of money when love comes in the window? When he is unable to resist the fatal charms of the newest four-wheeled enchantress he consoles himself by saying "Well, you only live once," or "I want to enjoy this before I am too old," and he signs a 24-month note for 80 dollars per month. And, even while he is mortgaging his homestead to get possession of his latest mechanical mistress, some designer is arranging for him to meet up with a more devastating type of beauty next year that will again turn his head"—CARL W. SUNDBERG, *Sundberg-Ferar, Detroit.*

As always DESIGNED AND BUILT FOR *FINEST* PERFORMANCE

Hanna H P HYDRAULIC Cylinders




Premium rings assure minimum oil slip.
Cylinder heads can be rotated for varied port location
Four air vents to each cylinder head.
Spring backed rod packings.
Turned, ground steel piston rod.
Steel piston finish machined after assembly to piston rod for perfect concentricity.
Self-sealing "O" ring gaskets.
Cylinder tube of accurately bored and honed centrifugally cast Meehanite.

for 50 years the Hanna nameplate has signified the finest engineered products. Meeting JIC Hydraulic Standards is nothing new for Hanna High Pressure Hydraulic Cylinders. They have always been designed, engineered and built to assure top-quality and dependable performance.

There is a complete line of standard Hanna H P Cylinders — for working pressures up to 1500 p.s.i. — to suit nearly every mounting requirement — to supply safe, smooth, economical power in thousands of industrial applications.

Send for **NEW CATALOG**

For complete information and specifications on Hanna H P Hydraulic Cylinders, ask for new Catalog 233-A

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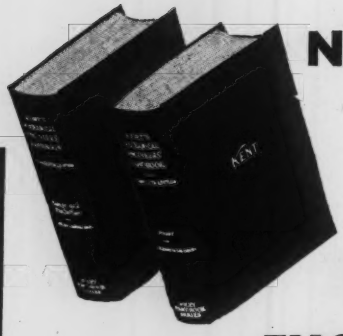

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SALES AND SERVICE PERSONNEL

LOCATED in Room 306, 410 West First St., Dayton, O., **Harold F. Barnes** is now sales representative in Ohio, for the R-B-M Manufacturing Division of Essex Wire Corp., having been transferred from the factory at Logansport, Ind. R-B-M sales activities in the St. Louis area are now being handled by **Jim Kress,** whose office is at 3435 Chouteau Ave.

♦

Appointment of **F. F. Roehll** as national sales manager of Eutectic Welding Alloys Corp. was announced recently. He has assumed full charge of the company's 200-man national field force which extends throughout the United States.

♦

Charles T. Button has been appointed director of sales for Holtzer-Cabot, division of National Pneumatic Co. Inc., manufacturers of special, small motors. Mr. Button comes to his new assignment from Howell Electric Motors Co., Howell, Mich., where he was vice president in charge of sales. He previously served as assistant sales manager of the electric motor division of Holtzer-Cabot for 18 years and for three years was sales manager of the electrical controls division of the Master Electric Co., Dayton, O.

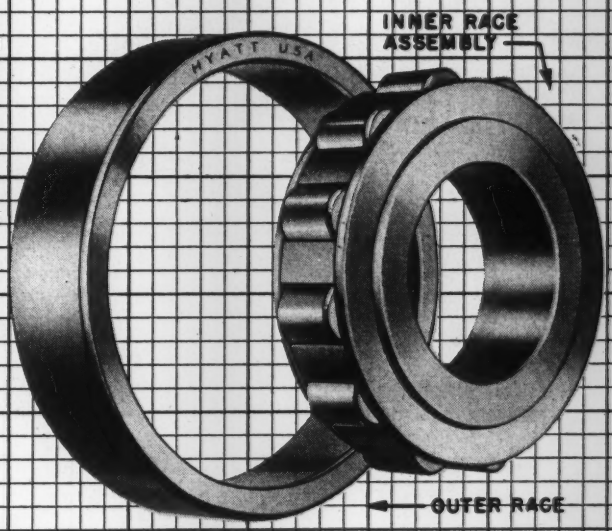
♦

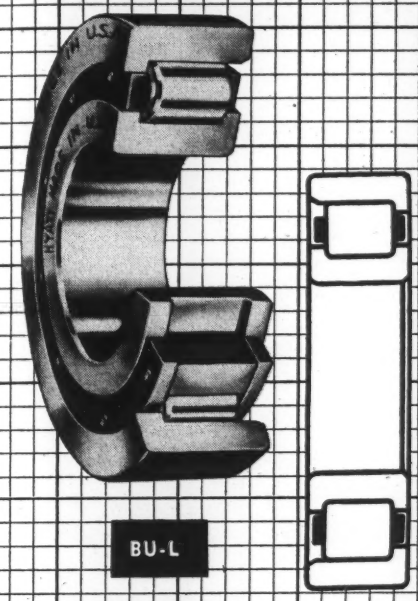
The Scintilla magneto division of Bendix Aviation Corp., Sidney, N. Y., has transferred **Roger B. Merritt** to its Detroit office to assist in coordinating all of the division's sales and engineering activities in the states of Michigan, Indiana and Ohio. Mr. Merritt formerly was sales engineer for the company on the eastern seaboard.

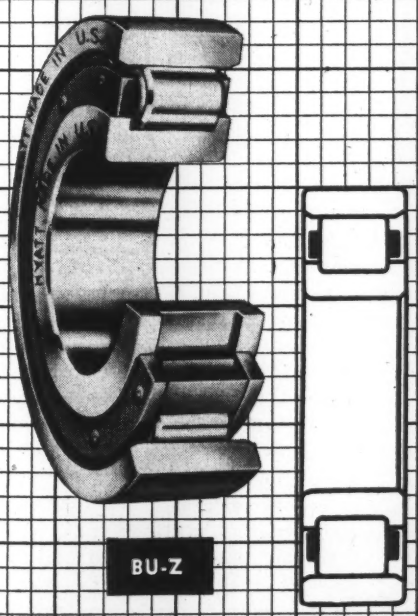
♦

Thomas Z. Hayward has been appointed general manager of sales for the group of 13 steel service plants of Joseph T. Ryerson & Son Inc. Succeeding Mr. Hayward as sales manager of the company's Chicago plant is **Roland W. Burt,** who began his career with Ryerson in 1923 and has served in various sales capacities since that time. Mr. Hayward has spent his entire business life with Ryerson, starting in the sales department in 1917 and progressing to the position of assistant general manager of sales, which he

For Separable Outer Race Bearings-- HYATT HY-LOADS







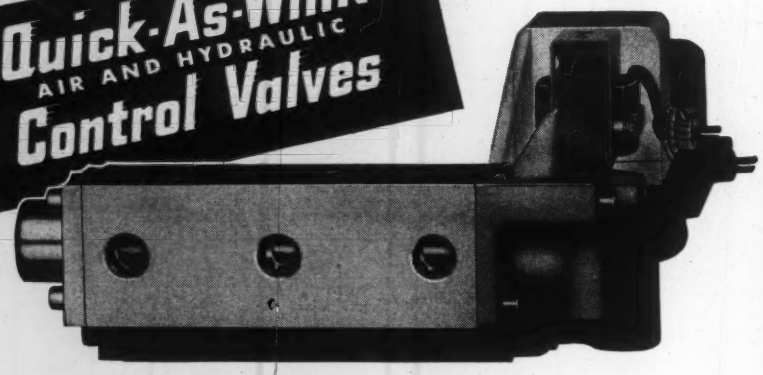
WITH the separable outer race type Hyatt Hy-Load Roller bearing it is possible to omit the outer race and mount the assembly on the shaft with the rollers operating directly in a housing of suitable hardness and finish. When space is limited for the housing bore or a bearing of larger size is desired, this feature of the BU-L and BU-Z Hy-Load Bearings makes them ideal for this type of application.

Another important feature is the complete interchangeability of bearing parts. Any outer race will fit any roller assembly of the same number. This permits the two bearing parts to be mounted in separable machine elements which are then brought together for assembly without worrying about selective fitting. This important Hyatt Bearing feature speeds final assembly, permits more efficient production planning and layout, and often leads to improvements in product design.

In addition to the Hy-Loads with separable outer races there are separable inner race and non-separable types each of which are made in a wide range of sizes. Full information about all Hyatt Hy-Load Roller Bearings is contained in Catalog 547 . . . a complete engineering guide to radial bearing selection and use. Write for your copy today. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

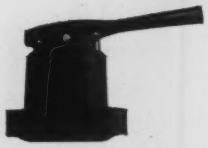
Specify Quick-As-Wink AIR AND HYDRAULIC Control Valves



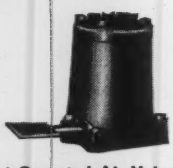
get *Millions of Cycles* of efficient, trouble-free operation

● Quick-As-Wink Solenoid Valves are unsurpassed for positive, trouble-free, dependable service . . . they give users millions of cycles of fast, high speed — and safe — operation. All parts are rugged yet weigh only a few ounces, simplifying electrical circuits, and minimizing wear and maintenance. Careful exhaust porting assures high air economy. ⅜″ to 2″ sizes. 2, 3 or 4-way actions. Bucking cylinder or double solenoid return. Send for the data sheets. Get full details about Quick-As-Wink, America's outstanding valve line, *today.*

Individual **DATA SHEETS** for Each Valve — give complete details. Write today!



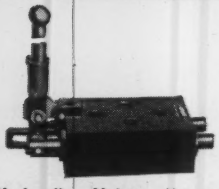
Hand Operated Air Valves— wide variety of uses. 2-way, 3-way, 4-way neutral position and compound exhaust.



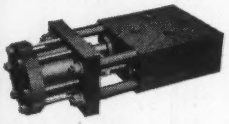
Foot Operated Air Valves— workman has both hands free, speeding production. 2-way, 3-way and 4-way actions.

Single Plunger Valves—for air or low pressure hydraulic service. Lever, pilot, cam, diaphragm or solenoid operated. 2-way, 3-way, 4-way actions.

Series "O" and "OE" Valves —for air or hydraulic service up to 125 PSI. Push-pull, cam, pilot, diaphragm and solenoid operated. ⅛″ and ¼″ pipe connections. 2-way, 3-way, 4-way and 5-way actions.



Hydraulic Valves—Up to 5000 PSI. Conservatively rated. ½″, ¾″, 1″ and 1½″ sizes. 2-way, 3-way, 4-way actions.



Hydraulic Valves—Up to 5000 PSI. Pilot cylinder operated. ½″, ¾″, 1″, 1½″ 2″, 2½″ 3″ and 4″ sizes 2-way, 3-way, 4-way actions.

Quick-As-Wink Control Valves

THE HIGHER THE PRESSURE • THE TIGHTER THE SEAL

Manufactured by **C. B. HUNT & SON, Inc.**

1946 East Pershing Street, Salem, Ohio

leaves to assume his new duties. It was also announced that **Allen P. Beckloff** has been named manager of the tubular products division of the Ryerson company, replacing Mr. Burt. Mr. Beckloff was formerly manager of the tubular products department of the company's Cleveland plant.

♦

The plastics department of Rohm & Haas Co. has appointed **Walter G. Lee** as sales representative, with offices in Room 205, 410 West First St., Dayton 2, O.

♦

D. J. Richards, vice president-sales of E. F. Houghton & Co., Philadelphia, has been placed in complete charge of all domestic and foreign sales activities since the recent death of **G. W. Pressell,** formerly vice president and director of sales. Mr. Richards will also act as director of advertising and will supervise the activities of the product development and the sales development department.

♦

Formerly western sales manager, **L. E. Noelch** has been promoted to the position of assistant sales manager for C. P. Clare & Co., Chicago relay manufacturers. Also, the Clare district sales office of **R. L. deVeer** has been moved from Boston to 82 Broadway, Cambridge 42, Mass.

♦

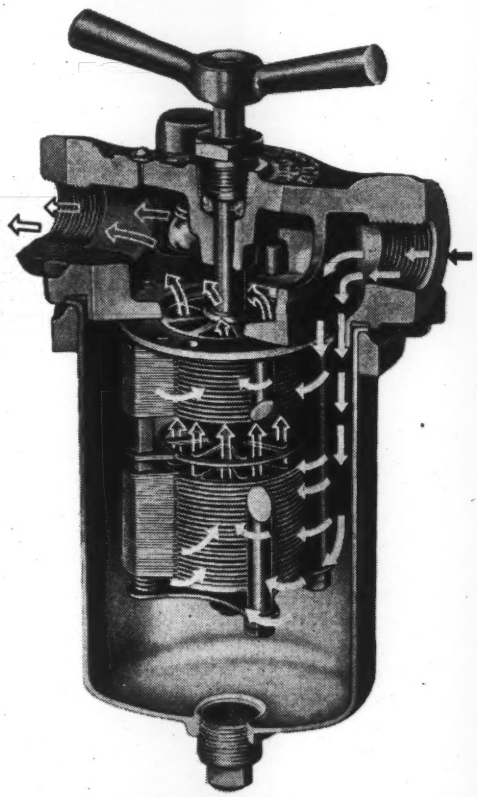
The Wellman Bronze & Aluminum Co., Cleveland, recently announced the appointment of **Donald Dingwall** as Chicago representative. He will handle the sales of the company's complete range of Well-cast magnesium, aluminum and bronze, permanent mold and sand castings, and Well-made wood and metal patterns.

♦

Manager of the application and service engineering divisions of the department, **A. K. Bushman** has been appointed manager of industry divisions in the sales organization of the General Electric Company's apparatus department. In his new capacity, Mr. Bushman will be responsible for supervision of the following divisions: Agency and distributor; aircraft, federal and marine; central station; industrial; and transportation. He will continue his present responsibility for the application, service and construction engineering divisions and will also correlate working relationships of the industry divisions with the department's sixteen product sales divisions and the sales districts. Concurrent-

There are many kinds of cleaning . . .

Here's the Only Fluid Strainer that Qualifies Across the Board



For general services—particularly lube and hydraulic systems . . . capacities from a few to more than 4000 gpm . . . wide ranges of fluids, viscosities, temperatures and solids—specify Cuno AUTO-KLEAN.

Cuno AUTO-KLEAN Strainer
All-metal, non-collapsible

POSITIVE cleaning—Cuno AUTO-KLEAN is *guaranteed* to remove all particles larger than specified. (Available spacings: from .0035 to .062 in.)

FULL-FLOW cleaning—Cuno AUTO-KLEAN cleans full flow *continuously* with minimum pressure drop, efficient on low pressure or gravity feed —or suction.

CONTINUOUS cleaning—Cuno AUTO-KLEAN is cleaned *without interrupting fluid flow.* Cleaner blades comb out accumulations between discs —periodically by hand or continuously by automatic means.

CONVENIENT cleaning—Single compact unit occupies no more space than usual partial-flow type; can be built-in or externally mounted with inlet and outlet in any position.

ECONOMICAL cleaning—Cuno AUTO-KLEAN needs no more attention than occasional turn of handle and emptying of sump. Lasts as long as the equipment it's installed on.

No Fluid Is Better than Its Filtration

CUNO

Complete Line
Fluid Conditioning
Removes More Sizes of Solids from More Types of Fluids

MICRONIC (Micro-Klean) • DISC-TYPE (Auto-Klean)
WIRE-WOUND (Flo-Klean)

New Bulletin on Designing for Efficient Fluid Straining

Find Out How AUTO-KLEAN Can Solve Your Fluid-Cleaning Problems

- ☐ Air Actuated Instruments
- ☐ Air Tools
- ☐ Bakery Machinery
- ☐ Balers
- ☐ Blowers
- ☐ Boiler Feed
- ☐ Coal Loaders
- ☐ Coating Machinery
- ☐ Combustion Equipment
- ☐ Compressors
- ☐ Controls
- ☐ Cooling Systems
- ☐ Crushers
- ☐ Diesel Engines
- ☐ Dip Tank Systems
- ☐ Drilling Machines
- ☐ Engines
- ☐ Gear Hobbing Machines
- ☐ Grinders
- ☐ Hobbing Machines
- ☐ Honing Machines
- ☐ Hydraulic Systems
- ☐ Incubators
- ☐ Instruments
- ☐ Lathes
- ☐ Lubricating Systems
- ☐ Machine Tools
- ☐ Meters
- ☐ Milling Machines
- ☐ Oil Burners
- ☐ Oil Well Drilling Equipment
- ☐ Paint Spray Systems
- ☐ Paper Machinery
- ☐ Pneumatic Devices
- ☐ Power Transmissions
- ☐ Presses
- ☐ Printing Presses
- ☐ Pumps
- ☐ Radial Drills
- ☐ Rolling Mills
- ☐ Scrap Balers
- ☐ Spray Systems
- ☐ Superchargers
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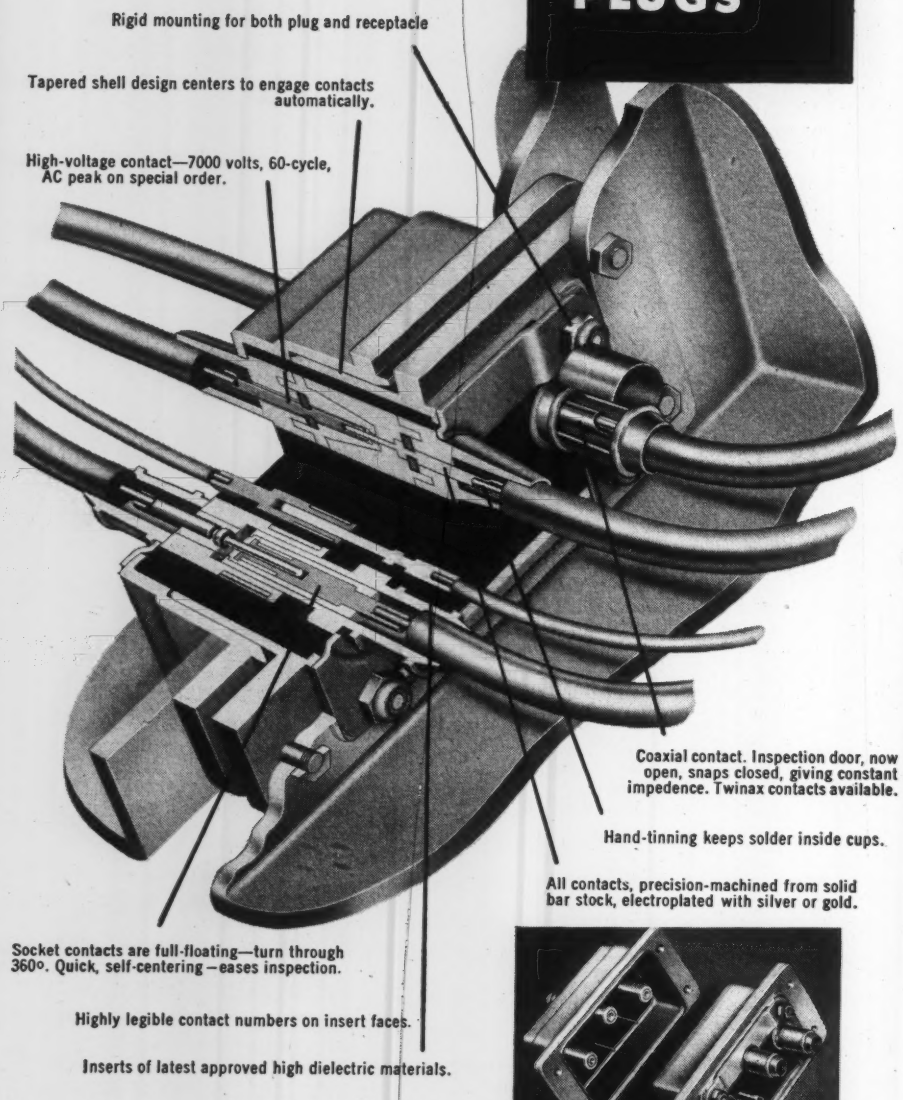
PLEASE ATTACH COUPON TO YOUR BUSINESS LETTERHEAD

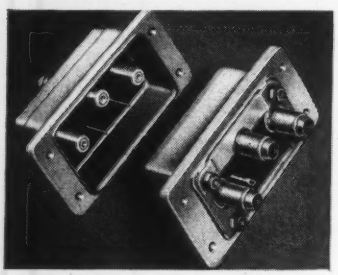
Here's why those in the know

—demand

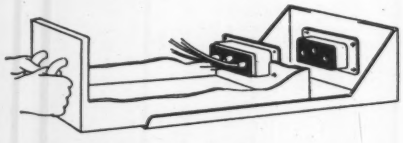
CANNON PLUGS


Rigid mounting for both plug and receptacle
Tapered shell design centers to engage contacts automatically.
High-voltage contact—7000 volts, 60-cycle, AC peak on special order.
Coaxial contact. Inspection door, now open, snaps closed, giving constant impedence. Twinax contacts available.
Hand-tinning keeps solder inside cups.
All contacts, precision-machined from solid bar stock, electroplated with silver or gold.
Socket contacts are full-floating—turn through 360°. Quick, self-centering—eases inspection.
Highly legible contact numbers on insert faces.
Inserts of latest approved high dielectric materials.

Your requirements are responsible for the 8 to 10 design advantages found in each type of Cannon Plug. That's why engineers know the specification is right when it calls for CANNON. The DP Connector Series is just one of many Cannon types —world's most complete line. Request bulletins by required type or describe connector service you need.



Insert arrangements are available with 2 to 45 contacts ranging from 15 amp to 200 amp capacity. Continuous shielding available in Coaxial and Twinax. Metal finish on shells for shielding and bonding . . . tin plating on aluminum. Other finishes available on special request.



Type DPD Connectors are permanent installations in rack and panel equipment . . . mate automatically . . . have weight and space-saving advantages over other connector types.

CANNON ELECTRIC

Since 1915

LOS ANGELES 31, CALIFORNIA

REPRESENTATIVES IN PRINCIPAL CITIES

ly, **Horace Zimmer,** New York district manager for the apparatus department, was appointed manager of districts for the department. He will be succeeded as New York district manager by **Frank A. Faron,** who has been the New York district's industrial divisions manager. Also, **Francis E. Fairman** was appointed general sales manager of large apparatus divisions, and **Arthur W. Bartling** was named general sales manager of small apparatus divisions in the same department. Mr. Fairman, formerly manager of sales for the department's transformer and allied product divisions in Pittsfield, will be located at Schenectady, N. Y., and Mr. Bartling will have his headquarters at Lynn, Mass. Succeeding Mr. Bartling as manager of sales of General Electric's fractional-horsepower motor divisions at Fort Wayne, Ind., is **Robert C. Hanna.**

◆

Associated with McGill Manufacturing Co. Inc., Valparaiso, Ind., for over 22 years, **Keith J. Brownell** has been made sales manager of the company's bearing division. For the past three and one-half years he has been assistant sales manager in this division.

◆

Royden C. Presley is the new district sales manager for the Birmingham area of Allegheny Ludlum Steel Corp. Until recently he had been manager of the Toledo, O., District sales office. Mr. Presley became associated with the company upon graduation from school in 1936 and since that time has worked his way from mail clerk in one of the manufacturing plants up through the company's advertising and sales departments.

◆

Robert G. Leary, who recently resigned his position as general sales manager of the Eastern Stainless Steel Corp. of Baltimore, has been appointed general sales manager of the Rigidized Metals Corp. of Buffalo.

◆

W. F. Lisman, former president of Leland Electric Co., has recently been appointed vice president in charge of sales at Brown-Brockmeyer Co., Dayton, O., manufacturers of electric motors and grinders. In expanding its national sales organization, the company has also appointed many new district sales representatives including **F. E. Schumacher,** Chicago; **A. M. Hill,** St. Louis, covering eastern Missouri, southern Illinois and Arkansas; **F. B. Larsen,** Philadelphia, handling eastern Pennsylvania, Maryland

NEW STANDARDS of ACCURACY with NEW TIMKEN® "00" BEARINGS

For lathe spindles, gear cutters, dividing heads, small rolling mills and other precision applications

MAXIMUM run-out tolerance only 75 *millionths* of an inch! That's the amazing precision achieved in the new Timken® "Double-Zero" bearing! It is twice as accurate as the Timken "Zero"—previously the most accurate Timken bearing made.

This sensationally low run-out tolerance opens up new opportunities for increased precision in a wide range of products. Already many manufacturers are using the new "00" bearing to increase precision in lathe spindles, gear cutters, dividing heads, small rolling mills, grinding machine spindles and other precision equipment. And production of the new Timken "00" bearings has been increased to meet the demand.

To make these new bearings possible, Timken Roller Bearing Company engineers have built specialized machine tools, developed measuring devices of extreme accuracy and perfected new manufacturing processes.

If you make a product that can benefit from greater bearing precision, you'll want to learn more about the new Timken "Double-Zero" bearing. It is produced in the types and sizes indicated below. For further information write The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

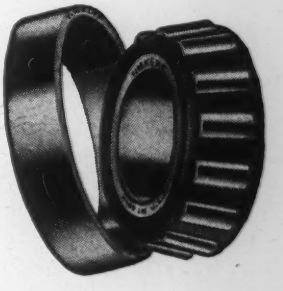
A PRECISION TIMKEN BEARING FOR EVERY REQUIREMENT			
CLASS	**"00" (DOUBLE-ZERO)**	**"0" (ZERO)**	**"3" (THREE)**
RUN-OUT	.000075"	.000150"	.000300"
TYPES AVAILABLE	Standard Single Row	Standard Single Row	All types
SIZE RANGE	Up to 10" O.D.	Up to 12" O.D.	Up to 12" O.D.

BE SURE TO VISIT OUR EXHIBIT AT THE IRON & STEEL EXPOSITION— CLEVELAND, OHIO BOOTHS 104, 105, 106, AND 107 SEPT. 26th THROUGH 29th

TIMKEN

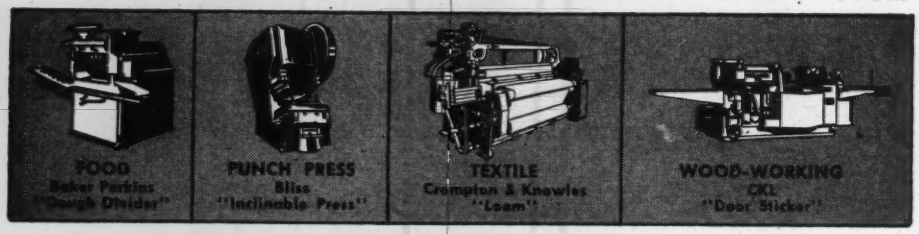
TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

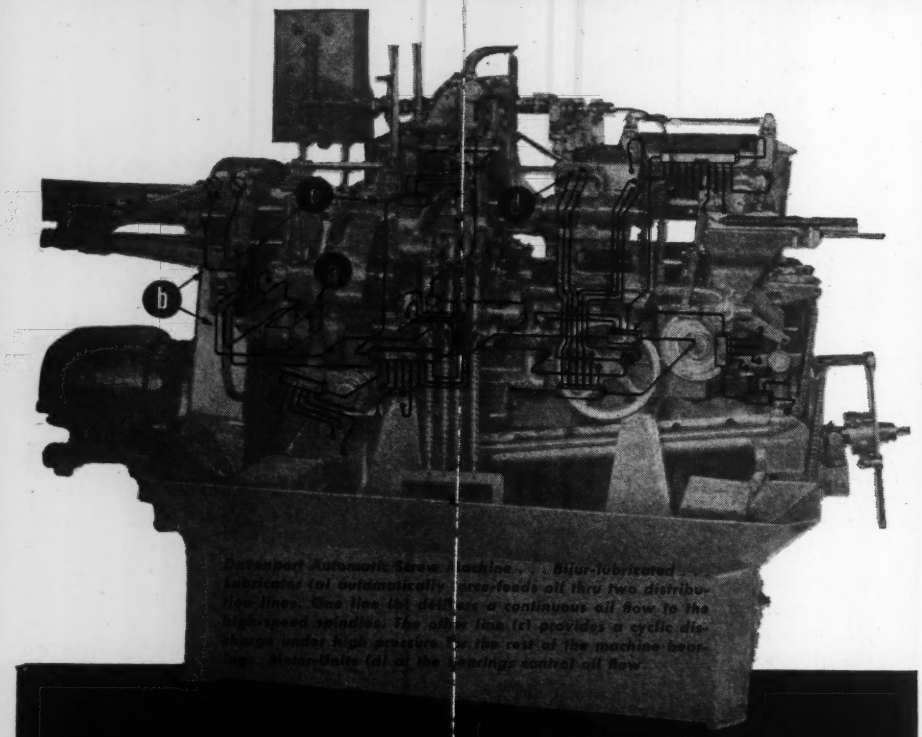


NOT JUST A BALL ◯ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◫ AND THRUST →◫← LOADS OR ANY COMBINATION →✳←

LEADING MANUFACTURERS BUILD IN THE BIJUR SYSTEM



automatic lubrication



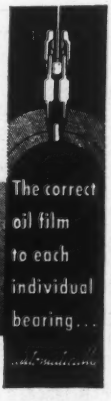
boosts production and cuts maintenance

Designing an automatic lubricating system into a machine doubles your prospects for user satisfaction.

First, maintenance time is converted into more time for production. A Bijur-lubricated machine oils itself during operation, doing away with wasteful down-time for lubrication.

Next, maintenance costs are cut as effective bearing life is lengthened. The Bijur system provides positive Meter-Unit control of oil flow *at the bearings*, considerably reducing bearing wear.

When you design that new machine, call on the Bijur engineer. Meanwhile, for further information write for "The Travels of Modern Lubrication."



389

BIJUR LUBRICATING CORPORATION

LONG ISLAND CITY 1, NEW YORK

and Delaware; **E. A. Linhart,** Pittsburgh, now covering eastern Pennsylvania; and **Louis Ellinger,** New Haven, covering the state of Connecticut. The Jack Gilbert Co., formerly representative in Missouri and Kansas, will now handle the line in western Missouri, Kansas, Oklahoma, and Nebraska, and **Ralph Cockroft,** Los Angeles, has been appointed to cover southern California.

♦

Recently announced was the appointment of **William R. Sandberg** as sales manager of Phoenix Manufacturing Co., Joliet, Ill. and Catasauqua, Pa. He will supervise sales and sales promotion for all four of the company's divisions—horseshoe, flange, forging, and Moldit rubber products. Each division will have its own sales manager and Mr. Sandberg will direct their work, dividing his operations between Joliet and Catasauqua sales offices and plants.

♦

Jack C. Schubert has been named to the position of Graphitar engineer for the United States Graphite Co. of Saginaw, Mich. Graphitar is the company's carbon-graphite product. Mr. Schubert will operate exclusively in this department in conjunction with the company's sales engineers and will work out of the home offices in Saginaw.

♦

Appointment of **E. B. Whittemore** as manager of the specialty spring steel department of the Cold Metal Products Co., Youngstown, was announced recently. This company produces Thinsteel, precision cold rolled strip steel.

♦

Louis R. Botsai has been appointed manager of the motor and control division of the Westinghouse Electric Corp. in Buffalo. He succeeds **Leon R. Ludwig,** who is now convalescing from a long illness and who has been appointed a member of the staff of vice president **John K. Hodnette** in Pittsburgh. Appointed to replace Mr. Botsai, **George H. McBride** was made manager of the company's gearing division in Pittsburgh. He has been succeeded as manager of sales of this division by **E. C. Hanks.**

♦

As part of the reorganization of its marketing department, Trumbull Electric Mfg. Co. of Plainville, Conn., has appointed **Yale T. Chaney** sales engineering manager of the eastern region and **Robert C. Wilson** sales engineering manager of the central region. Mr. Chaney has been with Trumbull since 1937. He was Trum-

YOU CAN BE **SURE**.. IF IT'S

Westinghouse

Pumps and Compressors

Submerged in 6 ft. of Water..Open Motor Pumps Sump Dry

When water rose accidentally in a sump of an eastern plant, an open Life-Line motor was covered by six feet of water. Someone pressed the starter, and the Life-Line pumped the sump dry. Outside of being covered with a thick coating of mud and [illegible] motor [illegible]

Can your pumps use *MOTOR STAMINA* like this?

We certainly do not recommend open motors be operated under these conditions—in fact, we say DON'T DO IT! But this actual example illustrates the real stamina built into Life-Line motors—stamina resulting from improved materials and manufacturing methods.

Take the stator, for example. Coils are wound of Tufvar wire—wire you can pound with a sledge, tie into knots, without disturbing the insulation. Pear-shaped slots enable coils to be slipped into place without forcing. A fiber wedge closes top of slot, seals against dirt and moisture. Multiple dips and bakes in Thermoset varnish give the stator a tough flexible film, resistant to oil, moisture, acid and alkali. That's why, in the above example, there was no winding short-out—even under water.

It costs no more to get this extra motor stamina. Simply specify Life-Line as the drive for your equipment. Ask your local Westinghouse representative for details and a copy of booklet B-3842, or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa.

J-21576

If you figure LIFE-COSTS... you'll figure LIFE-LINE

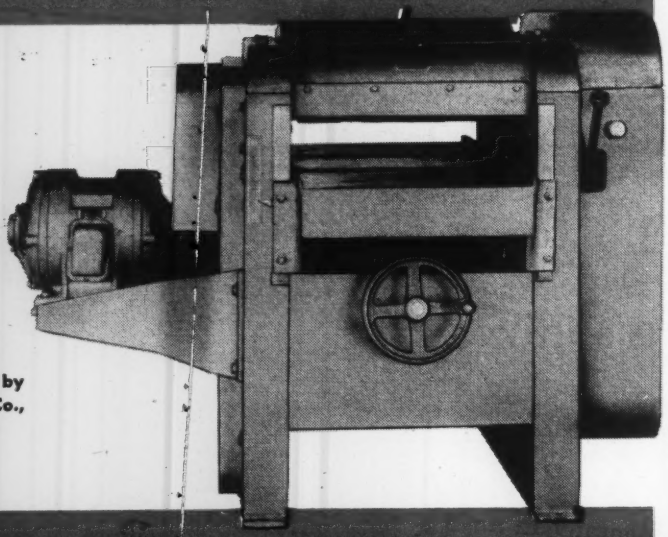
Westinghouse

Life-Line

Motors

POWERMATIC THICKNESS PLANER

is a heavy duty surfacer used in woodworking for production planing and to produce a precision finish required by cabinet and pattern shops. Manufactured by Powermatic Machine Co., McMinnville, Tenn.

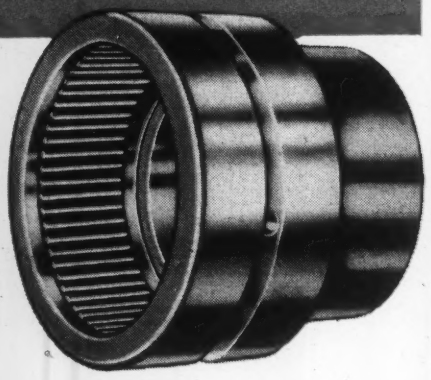


Gains 4 Important Advantages

by replacing plain bearings with

ORANGE ROLLER BUSHINGS

1. Solves limited space problem within bearing housings.
2. Eliminates hardening necks of idler and pressure rollers.
3. Eliminates former periodic bearing replacements and expensive roller replacements. Over two years using Orange Roller Bushings and still no replacements.
4. Obtains smooth-running, precision bearings which operate under varying pressures with little or no wear, under abusive conditions.



YOU can depend on Orange Roller Bushings for trouble-free, anti-friction protection of rotating or oscillating parts—large or small—under heavy loads or high speeds—in every kind of product from precision machine tools to heaviest equipment.

Orange Roller Bushings have high load carrying capacity in small diameters—run smoothly, quietly—provide long service life. Closer internal running clearances minimize possibility of mis-alignment of rollers. All raceways are through-ground.

Full range of stock sizes, from ½" to 8" shaft diameters. Write for Engineering Data Book.

ORANGE

ORANGE ROLLER BEARING CO., INC.

556 Main Street, Orange, N. J.

bull resident engineer at the General Electric Co. in Schenectady, N. Y., from 1945 until his appointment as distribution systems sales manager in 1948. Mr. Wilson joined the distribution systems sales division of the company in 1948, following engineering sales work in General Electric's industrial power division. Last year he was appointed manager of sales of Trumbull's Norwood, O., works.

♦

Several new appointments have been announced recently by the Bridgeport Brass Co. **Carl P. Quanz** has been promoted to plant manager in charge of all activities at the company's Indianapolis mills. He has been replaced as Chicago district sales manager by **Irving M. Malsch,** who has been with Bridgeport's sales organization for 15 years, for the past few years serving as Indianapolis district manager. Succeeding Mr. Malsch is **David L. Nesler,** who has been employed by the company for 13 years in their Chicago district sales office.

♦

A newly-created position of central sales manager, directing the sales of the Buffalo, Detroit, Cleveland, Cincinnati and Pittsburgh offices of Worthington Pump and Machinery Corp., has been filled by **William A. Meiter. John W. Stovall** succeeds Mr. Meiter as manager of the Buffalo district sales office.

♦

R. B. Crean was recently elected vice president in charge of apparatus sales at the Baldwin Locomotive Works, Eddystone, Pa., and **Andrew Liston** was placed in charge of the sales of all foundries and the handling of negotiations with the U. S. Government on special products. Mr. Liston will also continue in his present capacity as manager of hydraulic turbine and marine products department.

♦

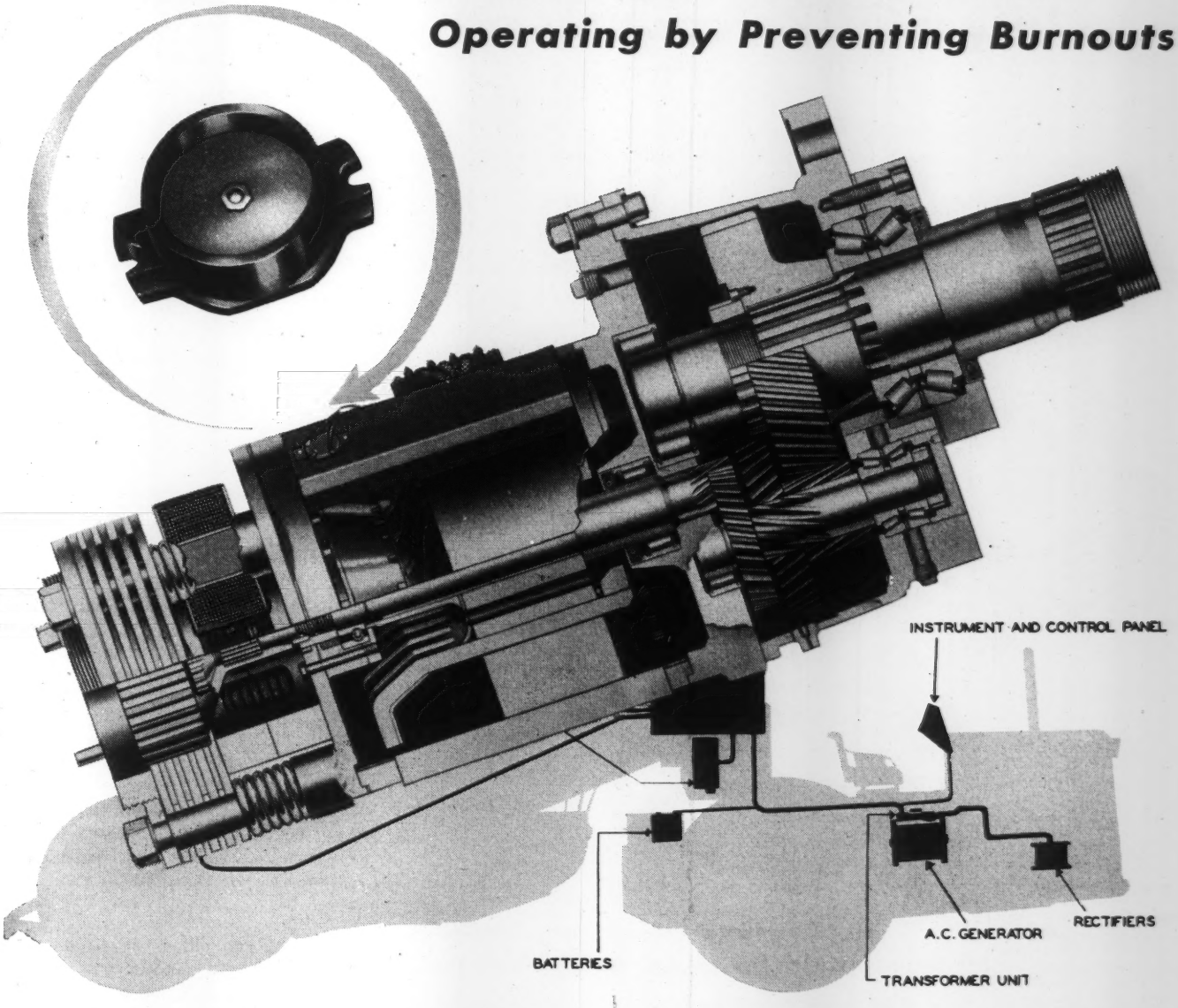
Non-Ferrous Permanent-Mold Inc., specializing in the manufacture of nonferrous permanent-mold castings, has named **T. S. Roderick** as general manager, with headquarters at the company's offices in Mansfield, O.

♦

Formerly vice president and marketing manager, **Kenneth R. Beardslee** has been named president of Carboloy Co. Inc., to succeed the late **Walter G. Robbins.** Mr. Beardslee joined the Carboloy organization as sales engineer in the Newark, N. J., office in 1930 and after several promotions was made vice president and marketing manager in 1948.

KLIXON PROTECTORS

Keep Husky Tournatorque® Electric Motors Operating by Preventing Burnouts



The Tournatorque motor, illustrated, provides *power at the point of action* in the famous R. G. LeTourneau earth-moving and construction equipment. Used in the electric controlled equipment, it simplifies operations by supplying the actuating power on LeTourneau equipment.

To assure continuous power without motor burnouts, LeTourneau Engineers use a built-in Klixon Protector in the Tournatorque motor. The reason — they know the value of positive motor protection . . . know that Klixon Protectors keep constant watch over the motor, always protecting it from possible burnouts which might occur from overloads.

Compact, easy to install, Klixon Protectors keep motors operating. They take into account the factors that cause motors to overheat and prevent them from burning out by cutting "off" the power should they become dangerously overheated. Then when they cool sufficiently, Klixon Protectors snap the power "on" again automatically or by manual reset depending on the type of protector used. Regardless of the type of motor-driven equipment you use, specify and insist that your motor manufacturer supplies you with motors equipped with Klixon Protectors. The additional cost is low, pays for itself over and over by preventing costly motor burnouts.

KLIXON

TRADE MARK REG. U. S. PAT. OFF.

SPENCER THERMOSTAT

Division of Metals & Controls Corp.

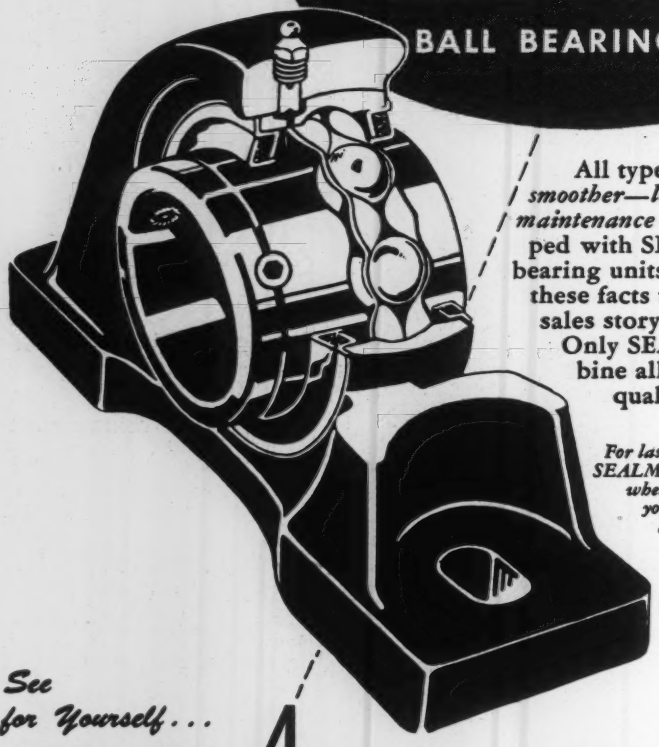
2509 Forest Street, Attleboro, Mass.

Put the BEST POSSIBLE Bearing Performance Into YOUR Products

by installing

SEALMASTER

BALL BEARING UNITS

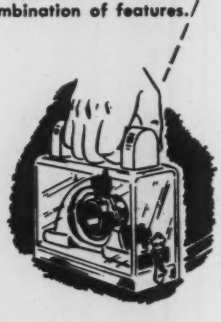


All types of equipment run *smoother—longer*—with *lower maintenance costs*—when equipped with SEALMASTER ball bearing units. Capitalize on these facts to supplement your sales story of other features. Only SEALMASTERS combine all essential bearing qualities *in one unit!*

For lasting satisfaction, specify SEALMASTER ball bearing units when designing or re-designing your line. Write today for a copy of SEALMASTER Catalog No. 845.

See for Yourself . . .

why SealMasters operate so smoothly...and last so long. Ask the SealMaster engineer to show you this cut-away pillow block which shows every detail of SealMaster's exclusive combination of features.



4 Big Reasons Why Your Machines Should Have SEALMASTER Bearings

1. **PERMANENTLY SEALED!** Felt-lined steel flinger rotating in labyrinth prevents entry of dirt or loss of grease.
2. **SELF-ALIGNING!** Bearing unit, with seals independent of housing, aligns itself without seal distortion.
3. **PRE-LUBRICATED!** Proper amount of lubricant is placed in bearing chamber before shipment . . . unit is ready for immediate use.
4. **NO HOUSING WEAR!** Patented locking pin and dimple prevents rotation of outer race in housing, and positions bearing for relubrication . . . No housing wear means quiet operation.

BEARING DIVISION

STEPHEN S-A ADAMSON MFG. CO.

18 RIDGEWAY AVENUE, AURORA, ILLINOIS — LOS ANGELES, CALIF. ★ BELLEVILLE, ONT.

Factory Representatives and Dealers in All Principal Cities

SALES NOTES

ESTABLISHMENT of an 11-state sales region to expedite future requirements of western industries for ball and roller bearings has been announced by **SKF Industries Inc.** The new region, with headquarters in San Francisco, will include territory now serviced by district offices in that city, Los Angeles and Portland and by the Denver branch office. This comprises the states of Washington, Oregon, California, Idaho, Utah, Wyoming, Montana, Colorado, Arizona, New Mexico, western Nebraska and the city of El Paso, Tex. J. C. Bowman, district manager at San Francisco since 1936, has been appointed regional manager.

♦

To insure the best field engineering service to customers and to potential users of their products, the **Lord Manufacturing Co.** of Erie, Pa., has announced the establishment of a field engineering department. Charles L. Freel has been appointed manager of this new department.

♦

Located at 137 Water St., Pittsburgh, Pa., the **Shields Rubber Co.** has been appointed distributor for O-rings made by the **Parker Appliance Co.** of Cleveland.

♦

One of the oldest brand names in the gas welding industry is now actively on the market again as a result of the incorporation of **Alexander Milburn Inc.,** 1231-1245 Ridgely St., Baltimore 30, Md. The new company will manufacture and market the Milburn line of oxyacetylene cutting and welding apparatus, regulators for oxygen, acetylene and other gases, accessories and supplies, and portable carbide lamps. Since 1945, Milburn equipment has been marketed by the **Black Manufacturing Co.,** Parkton, Md.

♦

Expansion of industrial wire facilities and reorganization of the industrial wire sales program of the **Electric Auto-Lite Co.** has been announced. The new Hazleton, Pa., plant of the company supplements wire production at the Port Huron, Mich. plant and places Auto-Lite in a

better position than ever before to service industrial accounts with all types of wire. Production from the Hazleton plant means faster service for customers in the East, and, in addition, new warehousing facilities have been established to serve customers better. Under the direction of K. L. Gackel, assistant sales manager, specially trained representatives are now in the field in important industrial areas. Division salesmen for the Wire and Cable Division include H. J. Lee, New York office; J. K. Galvin, Buffalo; F. F. Edie, Ohio district; J. M. Gerber and W. H. Schermer, Chicago; and A. R. Thornton, Michigan.

♦

Henceforth, the **Morse Chain Co.** of Detroit and Ithaca, N. Y., a division of **Borg-Warner Corp.,** will package its complete line of Morse roller chains and parts. This program is designed not only to expedite the shipping, storage and ordering of chains and parts, reducing handling costs to a minimum, but also to simplify inventory problems.

♦

The Cleveland office of the **Thomson Electric Welder Co.** has recently been moved to 760 Hippodrome Bldg., Cleveland 15, O.

♦

The **Standard Transformer Co.** of Warren, O., has appointed the **A & A Supply Co.,** with offices at Albuquerque, N. M. and Abilene, Tex., as its representative for the state of New Mexico and northwestern Texas. The complete line of Standard transformers will be handled through the A & A Supply Co.

♦

The Spokane branch of the **Electric Steel Foundry Co.** of Portland, Oreg., which has been located at S. 121 Monroe St. since 1943, has moved to a newly completed office and warehouse building at N. 1327 Washington St.

♦

The **Electric Products Co.,** Cleveland, has appointed **K. I. Clisby Associates,** Philadelphia, as district representatives for the eastern section of Pennsylvania, the southern counties of New Jersey, most of Maryland and the entire state of Delaware.

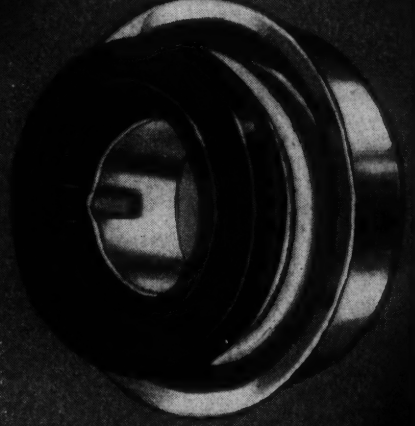
♦

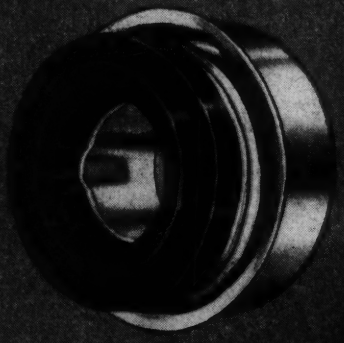
Graver Tank & Mfg. Co. Inc., East Chicago, Ind., fabricators and erectors of steel and alloy plate for the petroleum and process industries, recently opened a district sales office in Cincinnati at 426 Transportation

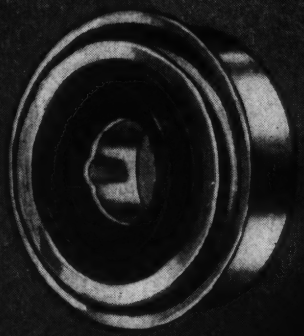
NEED A HIGH QUALITY, LOW COST SEAL FOR SMALL SHAFTS?

Try this "JOHN CRANE" 6A SEAL

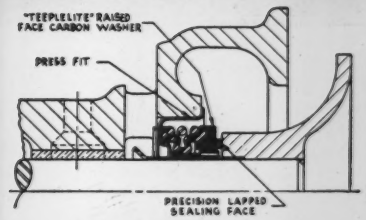
- *Cartridge-type*—quickly and easily installed on production lines; simple to replace.
- *Service-proven*—millions in use on small shafts, such as ¼", ⅜", ½" and ⅝".
- *End-face Sealing* eliminates all shaft wear. Once installed, this seal lasts for years.







ALWAYS SPECIFY "JOHN CRANE" SEALS. Our engineers in 32 field offices make sure that your installation stays *right.*



Typical water-pump assembly

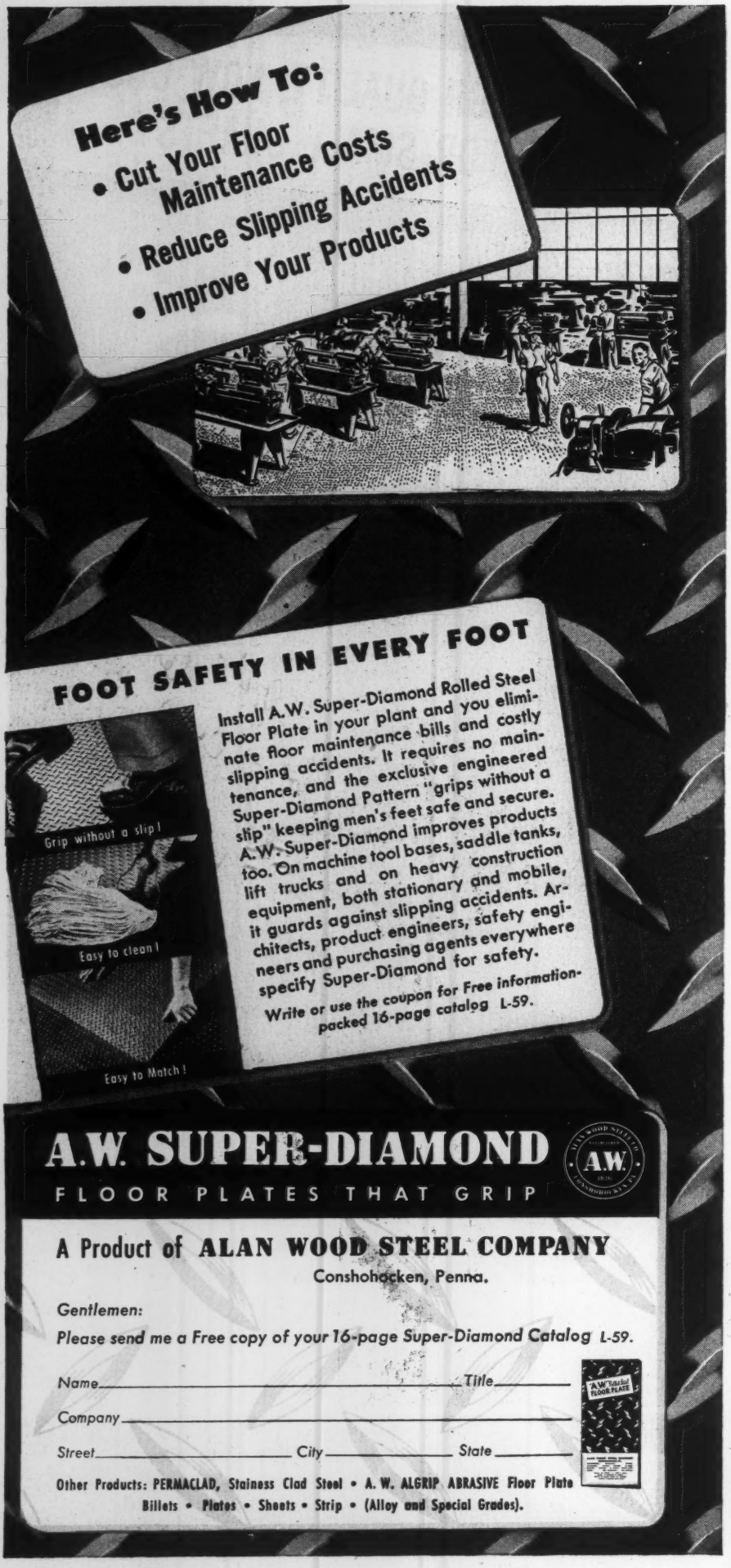
JOHN CRANE

PACKINGS AND MECHANICAL SEALS

CRANE PACKING COMPANY

1825 CUYLER AVENUE • CHICAGO 13, ILLINOIS

Offices in All Principal Cities in United States and Canada


Here's How To:
• Cut Your Floor Maintenance Costs
• Reduce Slipping Accidents
• Improve Your Products
FOOT SAFETY IN EVERY FOOT
Grip without a slip!
Easy to clean!
Easy to Match!
Install A.W. Super-Diamond Rolled Steel Floor Plate in your plant and you eliminate floor maintenance bills and costly slipping accidents. It requires no maintenance, and the exclusive engineered Super-Diamond Pattern "grips without a slip" keeping men's feet safe and secure. A.W. Super-Diamond improves products too. On machine tool bases, saddle tanks, lift trucks and on heavy construction equipment, both stationary and mobile, it guards against slipping accidents. Architects, product engineers, safety engineers and purchasing agents everywhere specify Super-Diamond for safety.
Write or use the coupon for Free information-packed 16-page catalog L-59.
A.W. SUPER-DIAMOND
FLOOR PLATES THAT GRIP
A.W.
A Product of ALAN WOOD STEEL COMPANY
Conshohocken, Penna.
Gentlemen:
Please send me a Free copy of your 16-page Super-Diamond Catalog L-59.
Name Title
Company
Street City State
Other Products: PERMACLAD, Stainless Clad Steel • A. W. ALGRIP ABRASIVE Floor Plate
Billets • Plates • Sheets • Strip • (Alloy and Special Grades).

Bldg., to expedite service to its customers in that area. John R. O'Connor, formerly at company headquarters in East Chicago, was made manager of the Cincinnati office.

♦

Illinois Tool Works, Chicago, has announced the selection of Lokuts as the new tradename for its line of torque type self-locking nuts. The nuts, distributed by the **Shakeproof Inc.** division of the company, are manufactured under an exclusive license from the **Boots Aircraft Nut Corp.,** Stamford, Conn., and were formerly sold under the tradename Tri-Lok.

♦

The **Hendey Machine Co.,** Torrington, Conn., has discontinued its sales office at 1534 Dime Bldg., Detroit, and hereafter will be represented in the Michigan territory by **Associated Machinery Sales,** 147 Jos. Campau, Detroit, Mich., and 1 North Main St., Clarkston, Mich.

♦

The West Virginia district office of the **Jeffrey Manufacturing Co.** has been moved from Huntington to 403 City Ave., Beckley, W. Va. E. H. Hebden continues as manager. Also, the company's district office in Cleveland, formerly in the Rockefeller Bldg., is now located in the Hanna Bldg., with J. W. St. John as manager.

♦

The **Liberty Equipment & Supply Co.,** 2022 East Seventh St., Los Angeles 21, Calif., has been appointed exclusive West Coast jobber for the **Marshall Steel Co.,** McCook, Ill. manufacturer of ground flat stock tool steel in water, oil and air-hardening types.

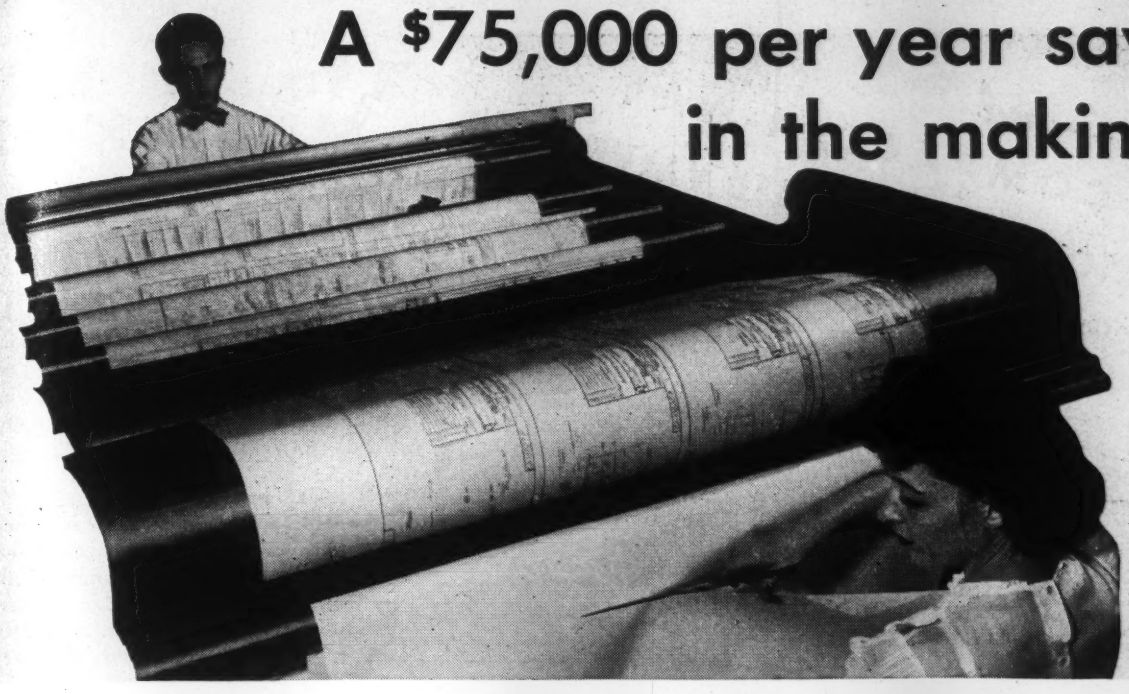
♦

A new branch office, located at 402 Swetland Bldg., Cleveland 15, O., has been opened by **Sciaky Bros. Inc.** Leo Gilbert is in charge of the new office, which will also serve as a co-ordinating office for the Sciaky branches in Dayton, O., and Buffalo, to give the best service to customers in that area.

♦

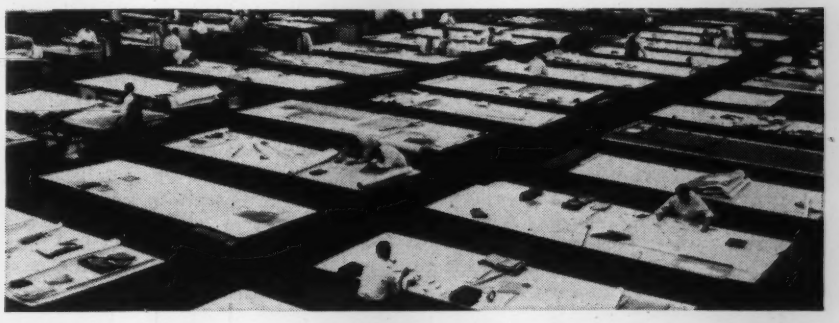
The **Republic Rubber Division** of **Lee Rubber & Tire Corp.,** Youngstown, O., has recently named two new distributors, the **Wetzel Equipment Agency,** 375 South West Temple, Salt Lake City, Utah, and the **Southern Marine & Supply Co.,** 10 East Bay St., Savannah, Ga. Both companies will carry a representative stock of Republic's industrial rubber products.

A $75,000 per year saving in the making . . .



Streaming off this continuous processing machine at the Ford Motor Company . . . are Kodagraph Autopositive prints—positive photographic intermediates of original drawings. *The answer to a $75,000 per year redrafting headache!*

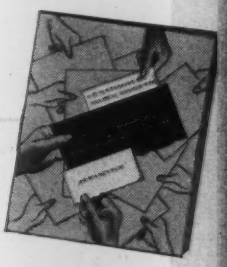
Before . . . Ford's valuable original drawings had a short life . . . had to do double duty in the drafting room and in heavy print production. In the latter operation, they were exposed to machine wear and tear, constant handling. Soon they lost their detail . . . produced illegible blueprints . . . which meant that new drawings had to be ordered from the drafting room.



Now . . . Ford's originals are filed away in the drafting room after Kodagraph Autopositive intermediates are made—available for reference and revisions only! All blueprints are produced from the "Autopositives," whose photographic black lines will not smudge or lose opacity . . . assuring highly legible prints even after hundreds of "run throughs." As a result of this simple change in routine, *redrafting costs are reduced by an estimated $75,000 per year . . . while the output of creative drafting is increased.* And print production is simplified, too . . . for Kodagraph Autopositives are not only longer-lasting . . . but can be printed at uniform, practical machine speeds.

Kodagraph Autopositive Paper

"The Big New Plus" in engineering drawing reproduction



You, too, can cut your drafting costs, get improved legibility, and simplify print production . . . by reproducing your drawings on this new, low-cost photographic intermediate paper.

You can turn out "Autopositives" quickly, economically . . . with your present print-making equipment and standard photographic processing. Or else you can order them from your local blueprinter. *It will pay you to get all the facts soon!*

MAIL COUPON FOR FREE BOOKLET

EASTMAN KODAK COMPANY
Industrial Photographic Division
Rochester 4, N. Y.

19

GENTLEMEN: Please send me a copy of your illustrated booklet giving all the facts on Kodagraph Autopositive Paper.

NAME_____ POSITION_____
(please print)

COMPANY_____ STREET_____

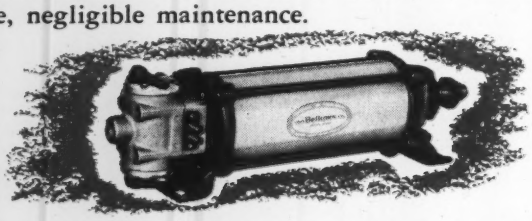
CITY_____ STATE_____

Kodak
TRADE-MARK

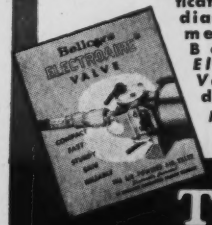
SO COMPACT it can be hidden behind a king size package of cigarettes; so fast even short stroke air cylinders can't match its speed; so safe it can be run submerged, flooded with coolant, or piled with chips; and so sturdily built we guarantee its solenoid-control units against burnout.

That, in a nutshell, describes the Bellows Electro-aire Valve — the electrically-controlled, air powered, air valve. It combines in one complete "packaged" unit a four-way directional valve, piston speed regulators, and low-voltage electrical controls.

You'll find its easy adaptability to the most complex electrically-controlled air circuits simplifies design. Its guaranteed freedom from "Burnout" assures minimum downtime, negligible maintenance.



Write for Your Free Copy of Bulletin AU-250 . . . specifications, wiring diagrams, dimensions of Bellows *Electroaire Valves*. Address: Dept. MD 950.



1155

● The ELECTROAIRE VALVE is standard equipment on all Bellows "Controlled-Air-Power" Devices arranged for electrical control. It is adapted for direct connection to or remote control of any air cylinder of suitable capacity.

The Bellows Co.
AKRON, OHIO

MEETINGS AND EXPOSITIONS

Sept. 18-22—

American Society of Mechanical Engineers. Instruments and Regulators Division Conference to be held at the Municipal Auditorium, Buffalo, N. Y. C. E. Davies, 29 West 39th St., New York, N. Y., is secretary.

Sept. 18-22—

Instrument Society of America. The fifth national conference and exhibit to be held in the Memorial Auditorium, Buffalo, N. Y. Richard Rimbach, 1117 Wolfendale St., Pittsburgh 12, Pa., is executive secretary.

Sept. 19-21—

American Society of Mechanical Engineers. Fall meeting to be held at the Hotel Sheraton, Worcester, Mass. C. E. Daves, 29 West 39th St., New York, N. Y., is secretary.

Sept. 23-26—

Packaging Machinery Manufacturers Institute. Eighteenth annual meeting to be held at the Homestead, Hot Springs, Va. Additional information may be obtained from Society headquarters, 342 Madison Ave., New York, 17, N. Y.

Sept. 25-27—

National Electronics Conference. Sixth annual conference and exhibition to be held at the Edgewater Beach Hotel, Chicago, Ill. Additional information may be obtained from Kipling Adams, Chairman, National Electronics Conference Exhibit Committee, 920 S. Michigan Ave., Chicago 5, Ill.

Sept. 25-27—

American Society of Mechanical Engineers. Petroleum mechanical engineering conference to be held at the Hotel Roosevelt, New Orleans, La. C. E. Davies, 29 West 39th St., New York, N. Y., is secretary.

Sept. 26-29—

Association of Iron and Steel Engineers. Annual iron and steel exposition to be held at the Cleveland Public Auditorium, Cleveland, Ohio. Additional information may be obtained from Society headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Oct. 12-13—

Gray Iron Founders' Society. The

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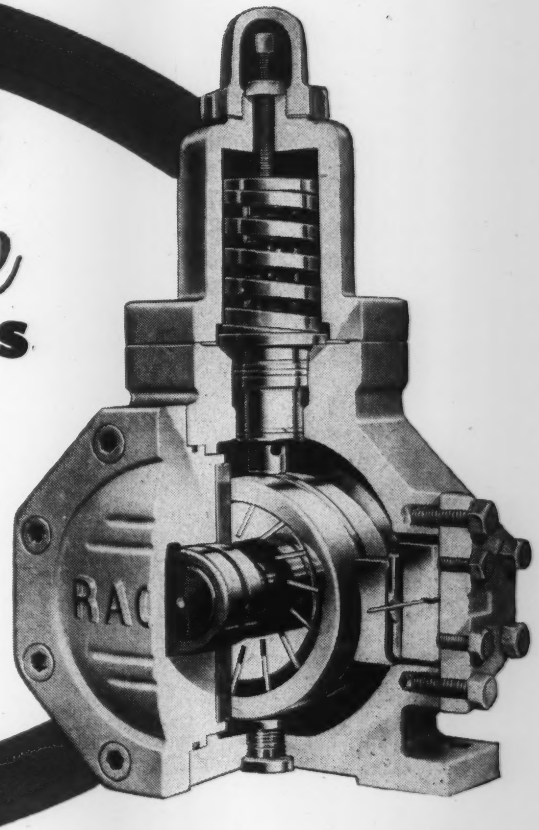

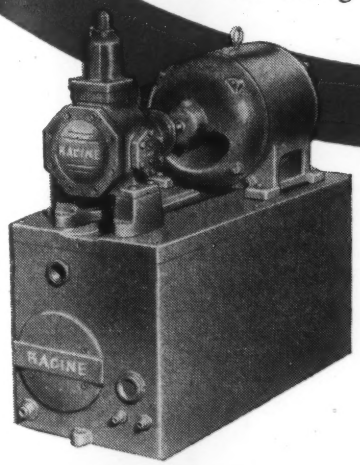

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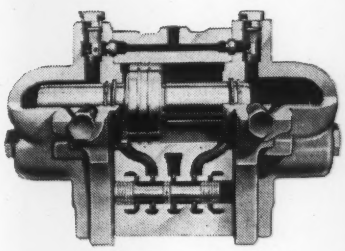

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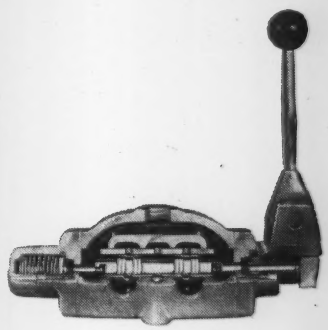

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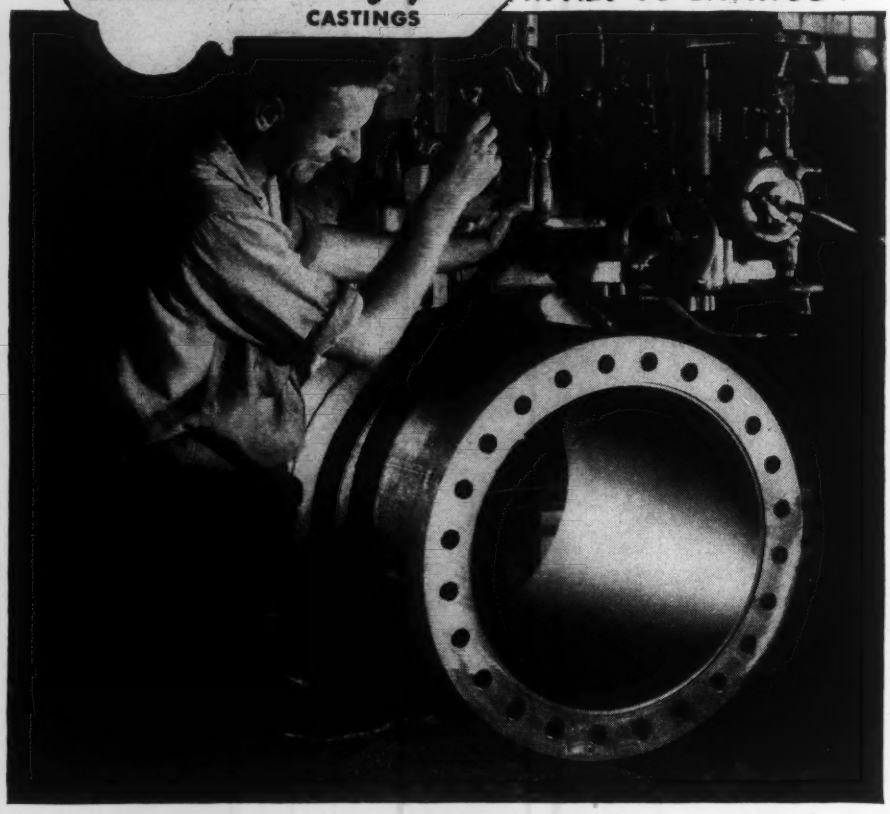

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MONEL METAL • NI-RESIST • MEEHANITE® METAL

22nd annual meeting to be held at the Netherland-Plaza Hotel, Cincinnati, Ohio. R. L. Collier, 210 National City Bldg., Cleveland 14, Ohio, is executive vice president.

Oct. 16-18—

Society of Automotive Engineers. Transportation meeting to be held at the Statler Hotel, New York, N. Y. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Oct. 16-20—

National Safety Council. The thirty-eighth congress and exposition of the National Safety Council will be held at the Stevens, Congress and Morrison Hotels. Additional information may be obtained from R. L. Forney, General Secretary, 425 N. Michigan Ave., Chicago 11, Ill.

Oct. 18-19—

National Conference on Industrial Hydraulics. Sixth annual meeting to be held at the Sherman Hotel, Chicago, Ill., under the sponsorship of the Illinois Institute of Technology and local sections of ASCE, ASME, SAE, Western Society of Engineers, ASLE, AIChE and IAS. Frank W. Edwards, Illinois Institute of Technology, 3300 South Federal St., Chicago 16, Ill., is conference secretary.

Oct. 18-20—

Society of the Plastics Industry. Annual national conference to be held at New Ocean House, Swampscott, Mass. William T. Cruse, 295 Madison Ave., New York 17, N. Y., is executive vice president.

Oct. 23-25—

American Gear Manufacturers Association. Semi-annual meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. Newbold C. Goin, Empire Bldg., Pittsburgh, Pa., is executive secretary.

Oct. 23-27—

American Institute of Electrical Engineers. Fall meeting to be held at the Skirvin Hotel, Oklahoma City, Oklahoma. H. H. Henline, 33 West 39th St., New York 18, N. Y., is secretary.

Oct. 23-27—

National Metal Congress and Exposition. The 32nd annual metal congress and exposition to be held at the Chicago International Amphitheatre, Chicago, Ill. W. H. Eisenman, 7301

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CHECK POINTS
OF FAWICK SUPERIORITY
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Fawick clutch and brake units provide a 360° friction surface and uniform-pressure, constant-velocity contact between the full width of the friction shoes and the drum. Greatest operating torque results from the application of operating pressure at the maximum diameter.
2 OPTIONAL CONTROL
Local or remote finger-tip control of instantaneous and smooth starting and stopping increases operating efficiency. Clutch or brake action can be sensitively regulated while units are in operation.
3 SELF-ADJUSTING
The rugged Fawick actuating element automatically compensates for wear of friction shoes. This insures complete engagement and dependable service from Fawick clutches and brakes.
4 LOW MAINTENANCE
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5 NO LUBRICATION
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Space requirements for Fawick installations are minimized due to the small number of moving parts and elimination of mechanical linkages. All conventional mounting arrangements are made with a substantial saving of vital axial space.
A Fawick clutch or brake of the correct type and size to meet your machine design and operating requirements is the best solution to your application problem. Check with Fawick before you buy.
All desirable clutch characteristics are built into Fawick Airflex units
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360° RADIAL CONTACT
SHOCK ABSORPTION
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Euclid Ave., Cleveland, Ohio, is managing director of the exposition.

Oct. 23-27—

American Society for Metals. Annual meeting to be held at the Palmer House, Chicago, Ill. W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, Ohio, is secretary.

Oct. 23-27—

American Welding Society. Annual meeting to be held at the Sherman Hotel, Chicago, Ill. J. G. Magrath, 33 West 39th St., New York 18, N. Y., is national secretary.

Oct. 23-27—

American Institute of Mining and Metallurgical Engineers. Fall meeting of the Metals Branch to be held at the Sheraton Hotel, Chicago, Ill. E. H. Robie, 29 West 39th St., New York 18, N. Y., is national secretary.

Oct. 23-27—

Society for Non-Destructive Testing. Annual meeting to be held at the Hotel Morrison, Chicago, Ill. Philip D. Johnson, Skokie, Ill. is national secretary.

Nov. 1-3—

American Society of Body Engineers. Fifth annual technical convention to be held at the Rackham Memorial Bldg., Detroit, Mich. Additional information may be obtained from Society headquarters, 100 Farnsworth, Detroit 2, Mich.

Nov. 2-3—

Industrial Management Society. Fourteenth annual time, motion and management clinic to be held at the Sheraton Hotel, Chicago, Ill., under the sponsorship of the Research Division. Additional information may be obtained from Society headquarters, 35 E. Wacker Drive, Chicago 1, Ill.

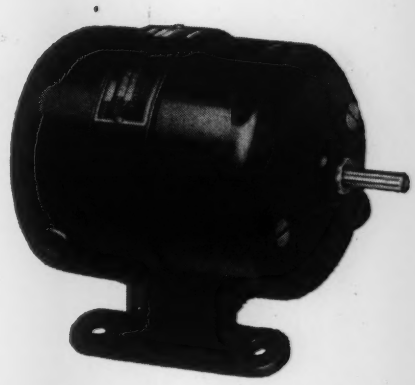
Nov. 2-3—

Society of Automotive Engineers. Diesel engine meeting to be held at the Knickerbocker Hotel, Chicago, Ill. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Nov. 9-10—

Society of Automotive Engineers. Fuels and lubricants meeting to be held at the Mayo Hotel, Tulsa, Oklahoma. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

EMC MODEL 500



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	Full Load	4M to 12M	1M to 8M
Power Rating (maximum)	Continuous	1/20 h.p.	1/25 h.p.
	Intermittent	1/12 h.p.	1/20 h.p.
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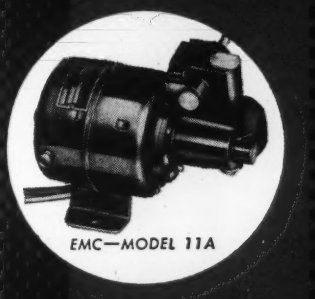

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For complete information about EMC model 500 or any of the famous EMC universal, shunt wound, or shaded pole motors and Cyclohm induction motors, write for handy reference literature and specification sheets. All EMC and Cyclohm motors can be furnished with gear units, 12 models, hundreds of ratios.

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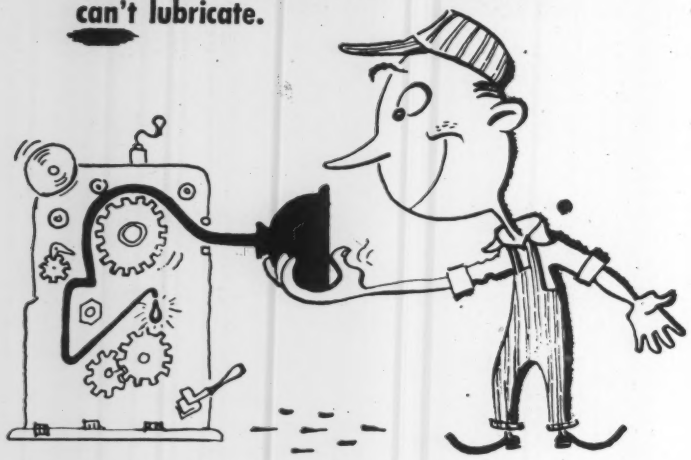
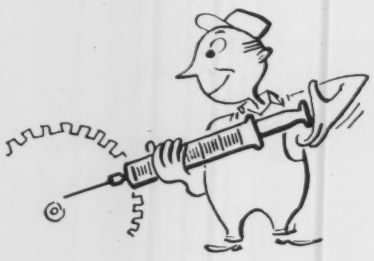
reaches vital parts ordinary methods can't lubricate.





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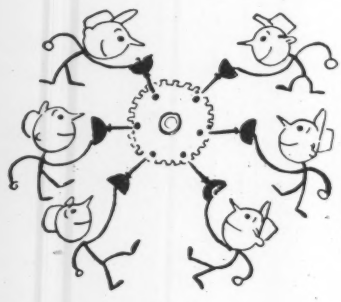

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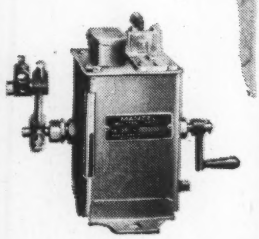

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DESIGN ABSTRACTS

Induction Heat Treating of Gears

INDUCTION heating has many inherent advantages for heat treating gears. It may be applied in a variety of ways to accomplish a wide range of results. At present the use of induction heating is limited to a few applications that have been worked out after much experimentation. These applications have proved to be satisfactory and it is expected that other applications will soon be made. The induction heating procedure must be worked out for each particular gear type and application. In order to support such a program the production must be reasonably high.

One of the chief advantages of using induction for heat treating gears is the reduction of distortion. Because induction heats a relatively small amount of metal in a short time, gears are produced with far less distortion than the conventional carburizing and through-heating methods. The spline bores of gears are not heated enough during the induction hardening process to cause distortion. Holding bore dimensions has been a problem in furnace-heated gears.

Induction-hardened gears are usually 1045 or 1050 steel. Some of these gears have replaced hardened and drawn alloy-steel gears with a considerable saving in steel costs.

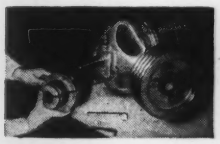
The cost of induction hardening gears will depend upon the quantity in production and the type of induction heat treatment necessary for the particular application. Where the production is reasonably high, the saving in producing induction-hardened gears is large. One manufacturer has estimated saving at $250 to $300 per day on a production of approximately 500 tractors. The saving per gear was as high as 16 cents. The average saving was 7 cents per gear for the 15 gears heat treated by induction.

Induction heating processes are better adapted to production layout than furnace heating methods. They more nearly approach one-at-a-time production which may be conveniently located with respect to the gear cutting equipment. The prob-

These Features Save You Money	For These Reasons	It's a Worthington—
1 Two-piece QD sheave—rim and hub separate	Mount light hub first, then slide heavier rim on tapered hub	EXCLUSIVE
2 Choice of one or two-piece assembly	Mount hub and rim separately, or loosely assemble hub on rim and slide on shaft together	EXCLUSIVE
3 Split hub	Easy to mount, even on oversized shaft	ORIGINAL
4 Clamp screw in hub	Holds hub in position on shaft while setting or removing rim	EXCLUSIVE
5 Taper-mated hub and rim	Mount easily in any position—no keyway between taper surfaces	ORIGINAL
6 Large, long pull-up bolts	Hold better and more uniformly	EXCLUSIVE
7 Friction cone grip	Tightening rim on hub gives positive press fit on shaft	ORIGINAL
8 Shaft key lock (set screw over keyway)	Prevents key from drifting	EXCLUSIVE
9 Quickly-detachable (QD)	Pull-up bolts used as jack screws to remove sheave rim	ORIGINAL
10 Interchangeable rims	Hubs for every bore—lower inventory cost	ORIGINAL
11 No realignment problem	Clamped hub holds shaft position—new rim tightens up in exact alignment	EXCLUSIVE
12 Choice of "A", "B", "C" and "D" grooves	"Tailor-made" grooves give proper belt "ride-out" for maximum life efficiency	ORIGINAL
13 I-beam spokes on driven sheave	Stronger—capable of carrying heavier load with less weight	EXCLUSIVE
14 Offset design of sheave	Reduces over-hang loads—increases bearing life	ORIGINAL
15 Worthington-Goodyear V-belts	Load-carrying cords in neutral axis reduce internal friction—each belt carries its share of drive load	ORIGINAL

How Does Your Drive Rate on the V-drive Scoreboard?

Here are 15 money-saving features of the most efficient V-belt drive. Only Worthington Multi-V-Drives give you all 15!



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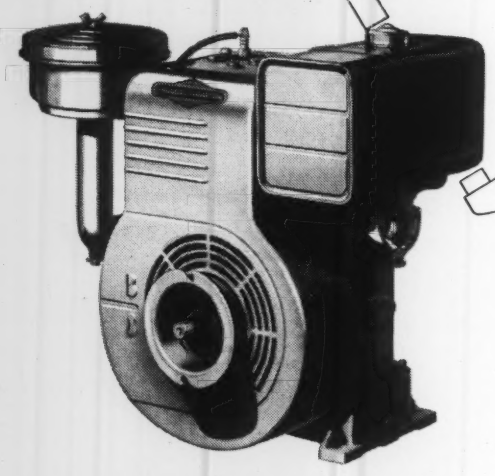

The most modern machines and tools for volume production with watch-like precision (many of them developed by Briggs & Stratton engineers), plus constant check and rigid inspection, are used to maintain uniform quality to meet the high exacting standards established by Briggs & Stratton — the result of the engineering and manufacturing experience gained in more than 32 years of continuous production, and the building of more than 4¾ million single-cylinder, 4-cycle, air-cooled gasoline engines.

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4 CYCLE BRIGGS & STRATTON GASOLINE ENGINES

In the automotive field Briggs & Stratton is the recognized leader and world's largest producer of locks, keys and related equipment.

lems of heating and storing batch lots is largely eliminated. Equipment has recently been developed that will process gears of different sizes at the same time with the same induction power generators. This makes a very flexible installation for manufacturers wno machine gears in small batches as well as those who have a continuous flow of gears to the hardening equipment.

At present there are two basic methods of induction hardening gears: through heating the teeth; and surface, or contour, heating the teeth. In the first method the entire tooth and the steel in the rim of the gear, at the base of the teeth, are raised above the hardening temperature. In the latter method only a surface layer of steel is heated above the hardening temperature. Although there are definite advantages by each system, each gear heat-treating application is worked out experimentally and the most suitable method chosen.

THROUGH HARDENING: In this process a band around the rim of the gear including the teeth is brought up to the hardening temperature by induction and suitably quenched. The process is much the same as flame hardening with the advantages of speed and ease of control. By induction the heat is induced in the steel below the surface and more power can be put into a given volume than is possible by flame heating where all the energy must be conducted into the surface of the steel.

Proper Heating Rate Essential

An important consideration in through-heating gear teeth is the rate of heating. The teeth must be brought up to hardening temperature without heating too much of the rim or web of the gear if the process is to be economical and distortion prevented. This requires a certain minimum power level. If the heating is too fast, the tips of the teeth will be overheated before the steel in the vicinity of the root is up to temperature. The selection of the power level used will depend upon a number of things, but in general a large tooth will be hardened at low power density while a small tooth may be hardened at considerably higher power density. The results obtained by through-heating methods depend on the power level, the tooth size, the quench, and the pretreatment given the steel.

CONTOUR HARDENING: There has recently been developed a two-frequency induction heating process that produces surface-hardened gears by induction. They are now used to re-

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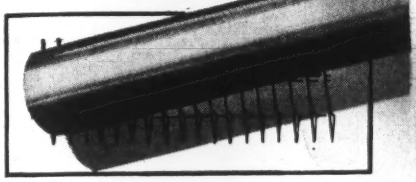
Wolverine TRUFIN*?

Trufin is the finned tube with the fins integral with the tube itself, thereby capable of withstanding vibration and extreme temperature changes. This tube saves space for you. It will



vide the required surface area in just a fraction of the space demanded by plain tube to meet the same requirements in heat exchangers. Or by utilizing the entire area you have available for tubing, you can substantially increase the efficiency of the operating unit.

Trufin is available in several alloys in many fin heights and spacings, in most popular sizes. Also in bimetal (copper inside, aluminum fins outside). Ask for our reports dealing with heat exchangers.

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Spun End Parts?

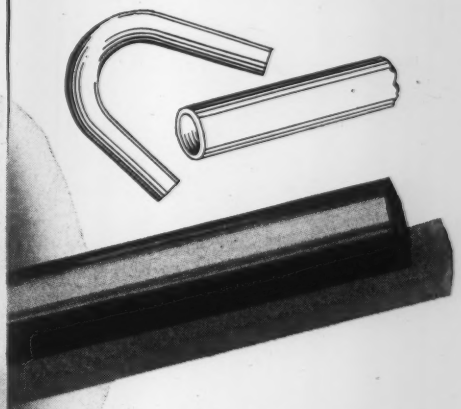
Tube can be formed into a multitude of shapes with economy. For instance, the ends can be spun to a smaller diameter —ending in a taper or in a round end entirely closed or partially closed. The tube can also be made with a bead around the circumference. In a word, the Wolverine Spun End Process offers opportunities for a wide variety of end treatments of tube and can save you the cost of extra parts that you now think seem necessary. And besides, eliminate assembly costs.

Our new brochure, Spun End Tube, is just off the press. Would you like a copy to acquaint you with possibilities for greater economy and efficiency that are within reach just by making a slight change in the design of a part?

Request a copy on your stationery.

Spun End Process is a patented process RE 22465.

Plain or Fabricated?



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Thus, alongside famous names in bearings, motors and other accessories listed in machinery manufacturers' catalogs, it is common to find Winsmith Speed Reducers. Such products improve performance. Such names help to sell.

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place carburized transmission gears in small and medium sized tractors. These gears have given excellent performance and have resulted in a considerable saving for the manufacturer. Gears from 5 to 16 diametral pitch have been hardened with this process.

One of the first requirements to consider in surface hardening small gear teeth (4 to 16 diametral pitch) is the heating time. The heating time must be short if thermal conduction is not to give a through-heated tooth. The smaller the tooth the shorter the heating time must be. In most cases the heating time is less than a second. The short heating time requires a high power density at a relatively high frequency (200 to 400 kc) if the surface of the steel is to be raised above the hardening temperature.

Early attempts proved that by this method alone hardness distribution around the tooth contour was not acceptable. To overcome this difficulty a system of preheating the gear by 10,000-cycle induction heating before the high-power high frequency is applied was developed.

The two-frequency method of surface hardening produces gears that are used to replace gears that formerly were carburized. Today, there are approximately two million of these gears in service in small tractors. During that time there has not been a gear failure that could be traced to the heat treating process.

At present the choice between through hardening and contour hardening with the two-frequency method is not easily made for teeth smaller than 4 diametral pitch. Much more work must be done before a definite line can be drawn between the two systems. *From a paper by John A. Redmond, engineer, Westinghouse Electric Corporation, presented at the AGMA Annual Meeting, June,* 1950, *in Hot Springs, Va.*

Metal-Powder Friction Material

METAL-POWDER friction material is a sintered mixture of metal and nonmetal powders developed to achieve desirable friction results. The most commonly used powders are copper, iron, tin, lead, graphite and silica.

Processing of the sintered-metal friction elements is similar fundamentally to other metal-powder products such as bearings, machine parts and filters. Dry powders of the constituent elements are mixed and blended in correct proportion and then molded at room temperature

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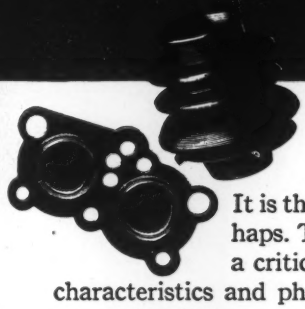

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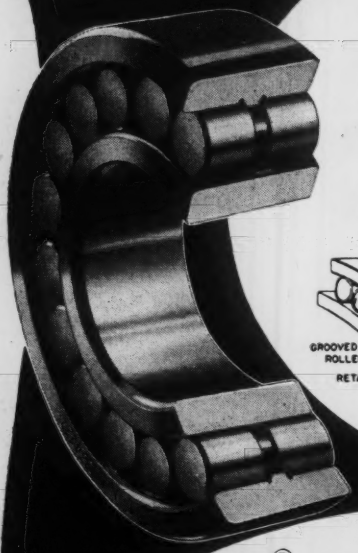

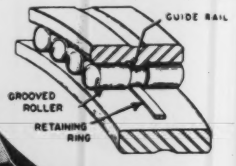

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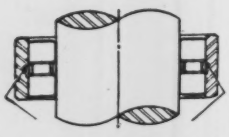

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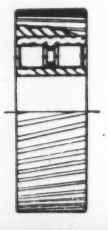

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under high pressures and sintered.

Primarily, metal-powder friction material is justified on its performance rather than its first cost. Its first cost is generally higher than that of competing friction materials, such as asbestos, molded or woven. Because of inherent higher material and processing costs, emphasis is placed on application design and efficient processing.

The size range of friction elements manufactured is probably considerably larger than generally offered in other fields of powder metallurgy. Friction elements range in weight from a few ounces to 140 lb. Compacts molded vary from ¼-oz to 40 lb of metal powders. Friction facings have diameters from less than 1 to 72 in. Compact thicknesses range from 0.020 to 1 in. Compacts as large as 224 sq in. are molded in one piece at 11½ tons per sq in. Another important factor in the manufacture of metal-powder friction material is chemical composition. Chemical composition can be related to wear, coefficient of friction, operating temperatures, and other factors.

Physical dimensions required for various friction applications pose different problems. Compact thickness is generally very small compared to length and width, accentuating the importance of green compact strength in relation to subsequent handling. Green compact growth and distortion are tooling probems. Offsetting this is the simplicity of contour of the compacts. With rare exceptions, compacts are of three simple shapes: ring, segment of a ring, or rectangular. It is desirable to mold in flat sections to assist in maintaining uniform density which helps maintain uniform frictional characteristics.

Supporting Member Added

A metal-powder part requires that a structural member be combined with the sintered material to take the mechanical stress of operation. The sintered mixture design for the best frictional characteristics is generally too weak psysically by itself for the required mechanical stresses. The structural member is usually sheet metal and takes the form of a core in a double-face or sandwich type friction element or a backing member in the case of a single-face friction element.

Because of the ability of metal-powder friction material to absorb energy at higher rates than most organic or mineral friction materials, it can be used at higher temperatures and

Close-up of tie plate and felt pad. The facilities of Grand Central Terminal are shared by The New York Central and the New York, New Haven & Hartford, two of America's great railroads, serving our five plants.

● Passengers who use the famous Grand Central Terminal in New York City never know that they are riding on felt, but such is the case. Felt pads are installed under the tie plates that hold the rails to the ties. Felt is used here to lessen the transmission of vibration to the structure of the Terminal, which has tracks on two levels, one above the other. In this application, felt probably meets its most severe test in vibration control. Another function of the felt is to reduce noise. Felt by American serves perfectly here, and lasts amazingly long, even under loads running as high as 25,000 pounds on each electric locomotive driving wheel. Replacements have been due chiefly to changes in rails and in tie plate design—the felt in some cases actually lasts as long as the steel rails!... If you have a problem in vibration control, get in touch with American Felt or any of its Sales Offices.

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at greater pressures and speeds. Metals can stand higher surface temperatures than organic materials before melting or disintegrating. This quality is important because more consistent friction properties are maintained over a greater range of operating conditions. Furthermore, for high-energy absorption applications, more compact designs are possible.

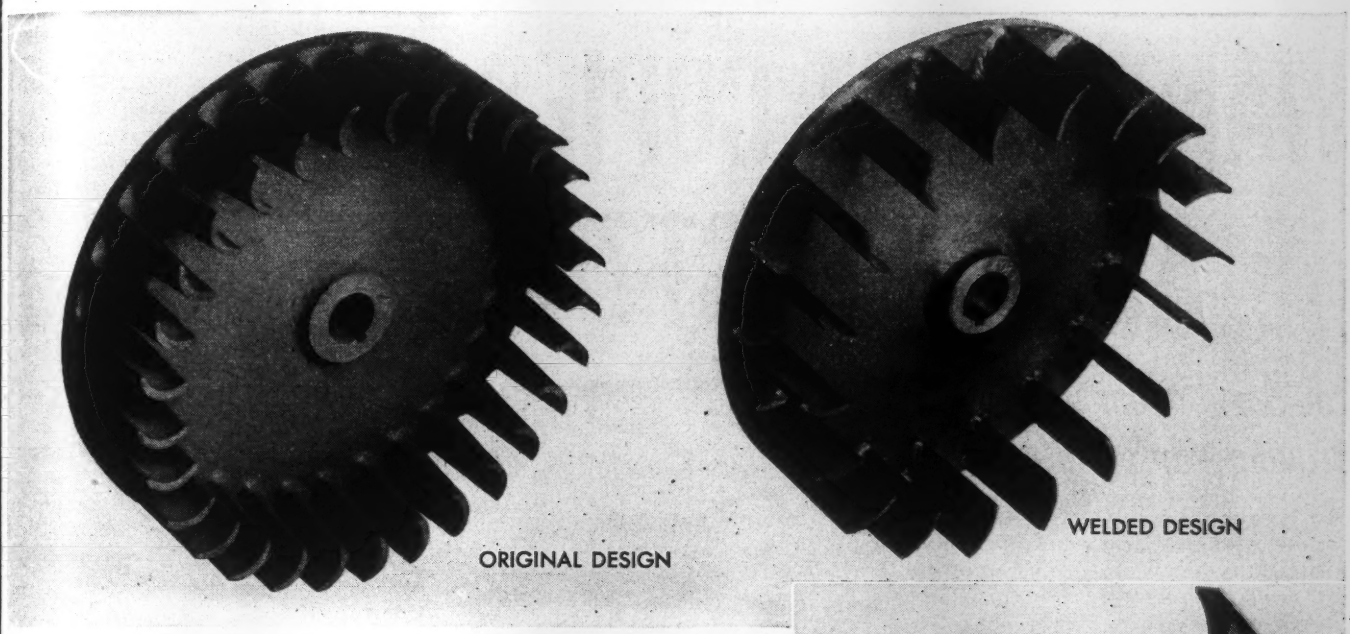
Metal-powder friction materials are not affected appreciably by climatic or other conditions such as heat, cold, dampness, salt water and fungi. Within a practical range, they are inert to chemical changes caused by heat, water, oil, solvents, fungi and salt water. Fluids will lubricate the friction surfaces and cause a lower coefficient of friction. The friction material can be cleaned of foreign substances and the original coefficient restored either by action of the opposing surface, wiping with a solvent, or refacing the material mechanically. *From a paper presented by L. P. Kane, sales manager, S. K. Wellman Co., at the Sixth Annual Meeting of the Metal Powder Association, April,* 1950, *in Detroit, Mich.*

Improved Seeing Improves Drafting

RESULTS to be expected from well planned lighting of drafting rooms are: reduced fatigue, fewer errors, increased quality and quantity of production, and improved employee attitude and morale. Improvement in any one of these aspects is often of sufficient value to justify the expenditures involved. When the benefits are realized in combination, there can be little question as to the economy of good seeing conditions. Continuation of marginal or poor conditions is a waste of financial resources and a hazard to personal health and welfare.

"How much light?" is a perennial question. Guidance codes such as the Illuminating Engineering Society's "Recommended Practice of Office Lighting" and the ASA "American Standard Practice for School Lighting" currently recommend 30 to 50 footcandles for school and office areas. Choice of a specific value within this range should be correlated to the severity of the tasks performed and to the time people are likely to be occupied with them. There is a growing tendency to consider this range as a minimum. Many find it economical to plan their lighting within the 50 to 100-footcandle range for which very accep-

Cuts Production Cost 20% with Welded Design



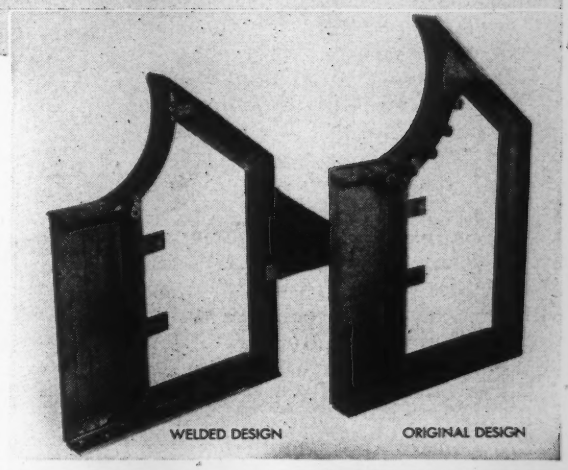
Lighter and stronger. *The all-welded steel flywheel at right has greater durability, higher operating efficiency . . . costs 20% less. Original 40 pound weight has been cut to 24 pounds.*

By H. A. Honstein, Production Manager
The Mobilift Corporation
Portland, Oregon

By converting the flywheels of our industrial trucks to welded steel construction, we now have a stronger, yet lighter, design that costs 20% less to produce. The weight of these flywheels has been reduced 16 pounds and the volume of air for cooling purposes increased by 40%.

The method of manufacture is simple. The disc and outer rim are cut from steel plate and the outer rim is fillet welded to the disc. Vanes formed from steel are held in a clamp-type fixture and fillet welded to the disc with "Fleetweld 7" using Lincoln "Shield-Arc" welders.

Similar benefits in greater strength at lower cost have been derived by redesigning other components of the truck, such as the side frame section, shown at the right.



Saves 30% in cost *by fabricating the side frame member entirely from steel. Shown below is industrial truck built by the Mobilift Corporation, Portland, Ore.*

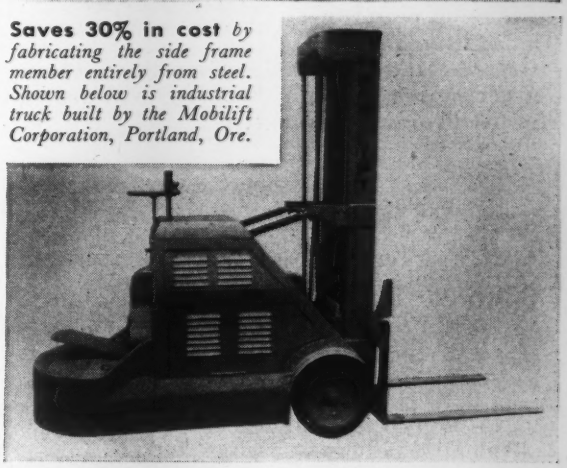


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table design techniques are available today.

Of equal importance to quantity are those factors representing the quality of the lighting. Shadows and reflections of light sources, either natural or artificial, are seldom an advantage. A shadow on the work is annoying and, more important, represents a loss in illumination and brightness. When reflections are seen in or near the work, they are extremely annoying and interfere with seeing performance. Lighting described as "diffused" tends to soften shadows. This minimizes their anoyance and to a considerable extent reduces their density.

Frequently, characteristics of the work introduce unnecessary limitations on the quality of lighting that will be acceptable. Use of shiny surfaces should be avoided. Gloss on many materials, instruments and accessories can be eliminated or reduced without significantly reducing their acceptability in other respects. In the drafting room, some progress has been made in introducing less glossy cloth, paper and instruments, although much is yet to be desired in this respect.

Vertical Boards Help

The real solution of these drafting-room seeing-performance problems is in the adoption of better materials and vertical boards. Certain problems that have been accepted as unavoidable in the past are thereby eliminated. Just as horizontal boards are generally raised 10 to 20 degrees, the position described as vertical is some 10 to 20 degrees from absolute vertical. This permits easy manipulation of drafting equipment and better utilization of light. The elevated board position requires drafting machines or attached straightedges and conventional triangle combinations.

At least five distinct advantages can be assigned to the use of vertical boards. Not the least important is normal healthy posture for the draftsman. Many can be seated in comfortable posture chairs. Second, the size of the board is not limited by the draftsman's reach. Boards may be raised or lowered to bring the actual work area to the draftsman. He may reach the extreme portions of very high boards by standing or by being provided with an elevated chair. The third advantage is the near-absence of shadows. Those along approximately vertical straightedge positions will be less than those encountered on horizontal boards. There are none along the horizontal straightedges. Maximum illumination is available down to the

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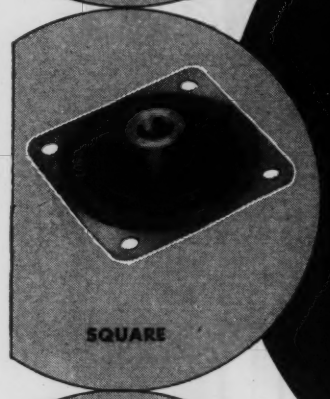

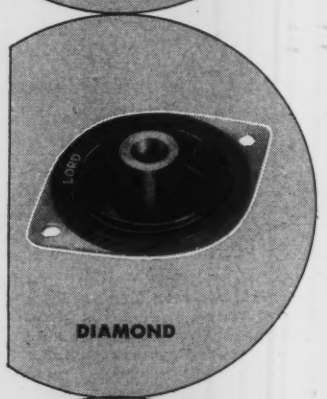

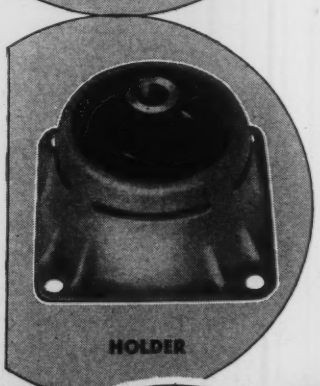

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actual point of work. Similarly, reflections are minimized with lighting systems of even questionable quality characteristics. The final advantage is better space utilization because 20 to 25 per cent more boards can be placed in a given area.

Surrounding Brightness Important

The eyes perform best when the brightness of the surface or surfaces surrounding the task is close to that of the task itself. The more immediate a surface is to the task or the larger it is in area, the more nearly its brightness should match that of the task. Although many desk and furniture surfaces have been so dark as to create unfavorable brightness ratios with work materials, this has not been the general situation with drafting boards. These are frequently made of light-colored wood and surfaced with light-colored materials. Surface finishes, however, have often been too glossy.

The need for balanced brightness extends beyond the immediate task surroundings. Brightnesses and brightness patterns over the whole seeing field influence the comfort of seeing and to some degree the ability to see. Hence, light colored, nonglossy surfaces are essential for the entire room.

The search for comfort has led to specification of minimum shielding and maximum brightnesses permissible for lighting equipment. It is recommended that filament lamps be used only in indirect or semi-indirect equipment for school, office and drafting room applications. Fluorescent lamps may also be used satisfactorily in such systems. In these instances, fluorescent lamps giving maximum lumens per foot should be selected for economy.

The brightness of fluorescent lamps is much lower than that of filament sources. In many instances they can be used in luminaries with either appreciable or complete downward distribution of light. With these designs, the specification of minimum shielding zones and maximum brightnesses becomes particularly important. Area of brightness is also a potent factor in determination of comfort and the orientation of equipment with respect to predominate viewing direction should be given special consideration. Experience leads to the generalized statement that lengthwise view is preferable with those units which transmit light through the sides that are parallel with the lamps. These are classified as luminous-sided luminaires. Those made with opaque sides are generally satisfactory when viewed either

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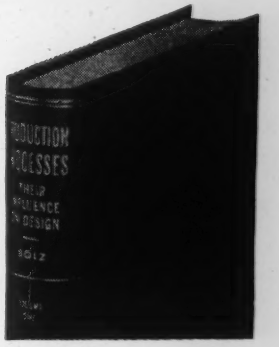
Are You Putting into Your Designs?



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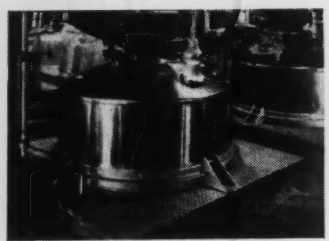

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crosswise or lengthwise. Appearance advantage of not seeing long lines of fixtures suggests crosswise view when comfort considerations permit. The lengthwise view with either type is particularly comfortable when the lamps are shielded to 35 to 45 degrees in this direction.

Attempts or proposals to make drafting room lighting something radically different from that for classrooms and offices are not warranted. Lighting for drafting rooms should depart from general school and office practices only in the directions of higher quality and quantity.

The recommendation to use higher illumination levels introduces frequent use of fluorescent lighting with appreciable downward components. In many cases units are used without diffusing media between the light sources and the work planes, direct viewing comfort being achieved through shielding and louvering techniques. Whenever a straightedge on a horizontal board is parallel with the lamps in such systems, sharply defined shadows may result. The density of such shadows need not be deep but their sharpness causes annoyance and interferes with efficient drafting. The vertical board, with its many other attributes, eliminates this problem. If the traditional horizontal board position is retained, this shadow interference may be minimized by rotating or turning the drafting table 15 to 20 degrees. This displacement eliminates the sharp definition of shadows for the major straightedge positions. It may still develop along straightedges parallel with the light sources but is eliminated at the horizontal, 30, 45, 60 and 90-degree positions.

Turning Lights Impractical

Resistance to turning drafting boards has sometimes led to turning the lighting system. This practice is not recommended. It often increases the cost of installation. A rotation of 45 degrees is more practical to install than one of 15 to 20 degrees, but this retains the shadow problem along one 45-degree position, which is frequently a major one. Such lighting systems have slight logic for drafting applications and practically none for any other type of occupancy. The same result can be achieved by turning the drafting boards and, more important, the entire problem of shadows can be eliminated by the use of vertical boards.

—From a paper presented by R. L. Oetting and W. E. Potter, lamp department, General Electric Co., at the ASEE Annual Meeting, June, 1950, in Seattle, Wash.

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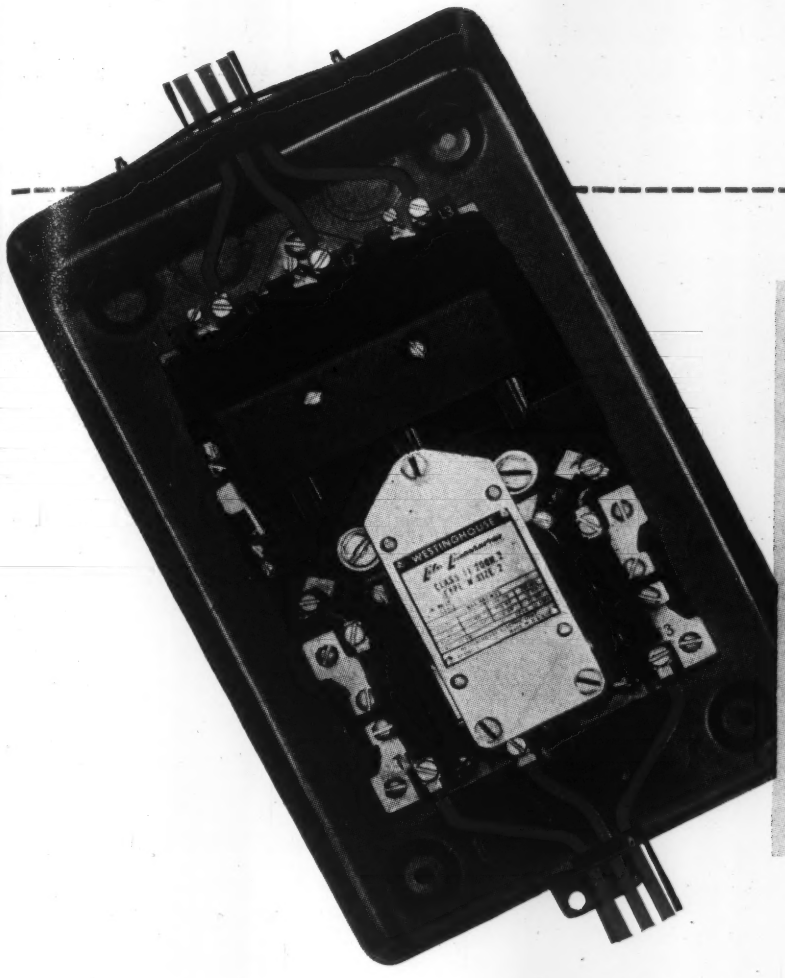

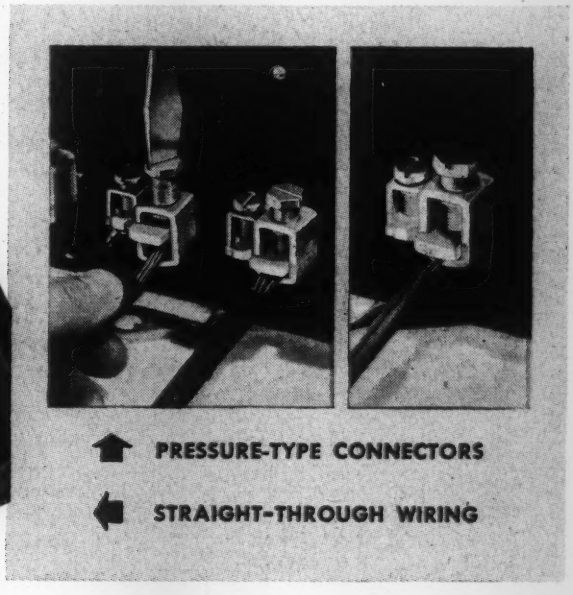

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REFRIGERATED CABINETS: Remote type units for ice cream storage. Five models have bulk storage capacities of 20, 25, 35, 50 and 65 gal. White, all-steel cabinets 10 inches shorter than comparable self-contained cabinets. Compressors can be installed in any convenient near by location. *Frigidaire Div., GMC, Dayton, O.*

ICE MACHINE: Makes de-aerated ice for use in carbonated beverages, salads, deserts, displays, etc. Machine is self-contained, has capacity of 2000 lb ice per day. Designed for use in restaurants, hotels, stores, etc., or any place requiring 500 lb or more of crushed, cracked or shaved ice per day. Ice comes from machine in ribbon form. *York Corp., York, Pa.*

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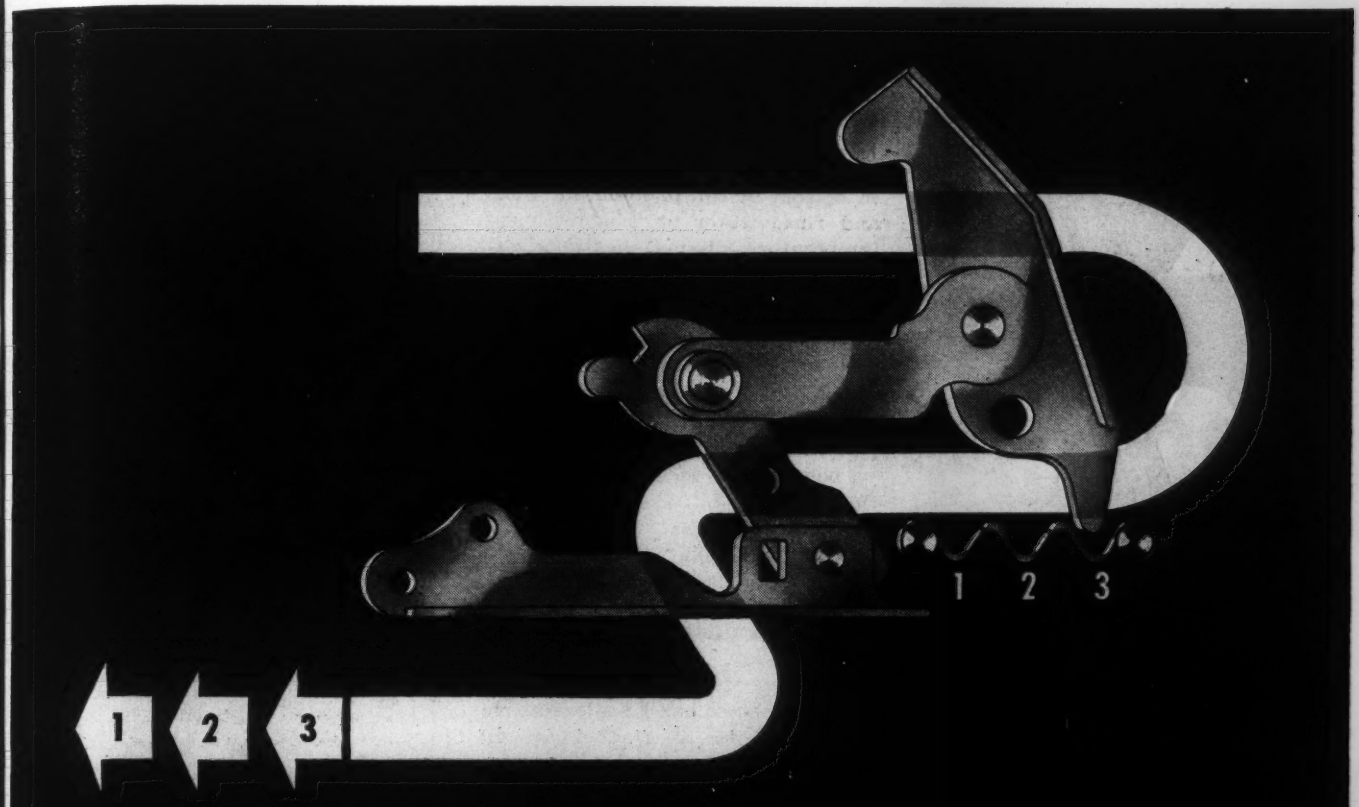
REFRIGERATOR: Capacity, 7.4 cu ft. Freezer chest extends across top, holds 30 lb frozen foods. Ice trays have capacity of 56 cubes or 8 lb of ice. Some of aluminum shelves are adjustable. Total shelf area 15.1 sq ft plus 1.78 sq ft in freezer chest. Two sliding Hydrators have combined storage capacity of 18½ qt. Refrigerated by sealed rotary Meter-Miser compressor unit. *Frigidaire Div., GMC, Dayton, O.*

AUTOMATIC ELECTRIC DISHWASHER: Top-opening model washes and



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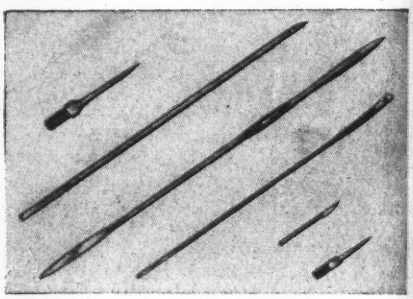

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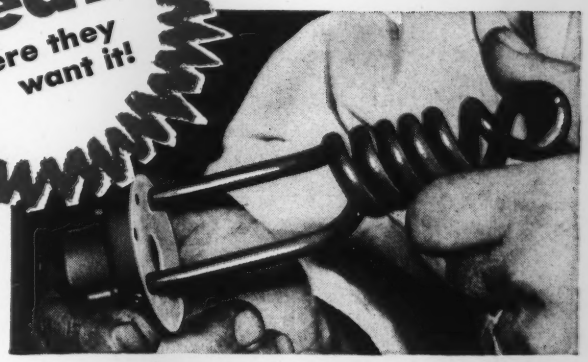

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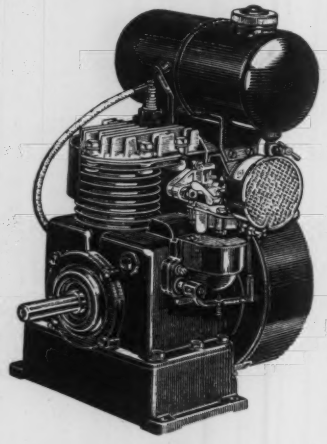

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CRANE CAB AIR CONDITIONERS: Ventilate, heat and provide dust and fume protection for crane operators. Fan sections can be rotated 90 degrees to discharge fresh air from top or either side of cab. For cold weather, fresh air heated by electric strip heaters automatically controlled to maintain 68 to 72 F temperature. Units operate on a-c or d-c. Dimensions; 16 by 26 by 42 in.: if fume removal not required, unit measures 16 by 26 by 26 in. *Dravo Corp., Pittsburgh, Pa.*

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Manufacturing

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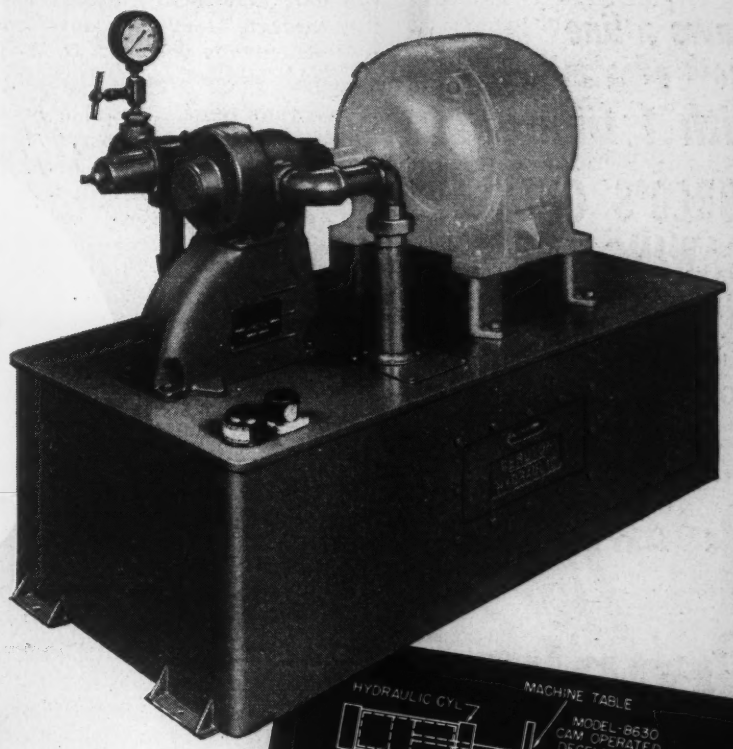

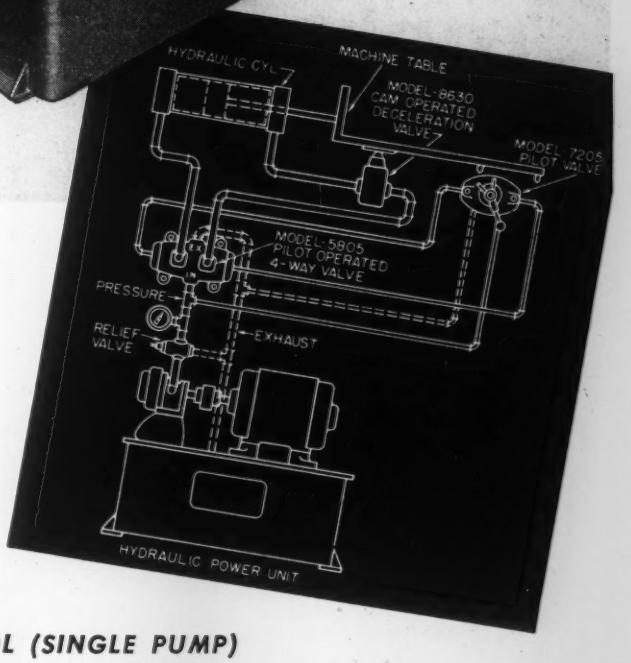

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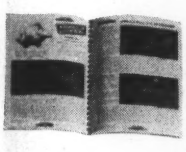

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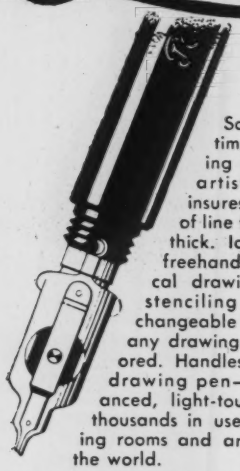

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ELECTRIC DRILL: Portable hand drill designed for deep boring in heavy timbers, creosote planking, and sappy wet lumber. Built-in toggle type switch reverses drill. Capacity; ½-in. in metals, 1 in. in wood. Weight, 8¼ lb. Universal a-c/d-c motor runs at 550 rpm no-load speed. *Cummins Portable Tools Div., Cummins Business Machines Corp., Chicago, Ill.*

DIE FILING MACHINE: For machine filing of intricate die contours. Includes improvements in chucking arrangements for files, saws and stones. Standard operating speed, 375 to 500 strokes per minute; 250 to 650 strokes per minute available as specials. *Illinois Tool Works, Chicago, Ill.*

FORCING PRESS: Hydraulically-operated, 10-ton, floor-mounted model. Table is 36 in. above floor, measures 18 by 20 in. Daylight opening, 22 in.; reach, 10 in.; max stroke, 12 in. Powered by 5-hp vertical motor and 11 gpm constant volume pump, with relief valve adjustable between 10 and 100 per cent capacity. Single manual lever control standard, dual manual lever control and sensitive pressure control available. *Hannifin Corp., Chicago, Ill.*

WELDERS: Light, bench type spot welders for high-speed assembly of small parts. Adaptable to projection welding. In 5, 10, 15 or 20 kva capacities. Two smaller models air cooled, two larger models water cooled. All rated at 50 per cent duty cycle according to RWMA standards. Standard equipment includes eight-point heat regulator. Force of 540 lb available on welding pressure stroke. *Thompson Electric Welder Co., Lynn, Mass.*

TABLE-TOP WELDER: For welding household mixer base units. Has 10 adjustable, self-centering welding guns and five series transformers rated 35 kva at 50 per cent duty cycle. Control cabinet regulates squeeze-weld-hold-off times. Welds 520 units per hour. Locating fixtures for positioning guns adjustable to handle various shapes. *Sciaky Bros. Inc., Chicago, Ill.*

DRILL PRESS: Low-cost, 14-in. model for continuous industrial service. Includes automatic belt tension device, adjustable feed handle and one-piece head casting. Drills to center of 14¼-in. circle. Max drill size in steel, ½-in.; spindle run-

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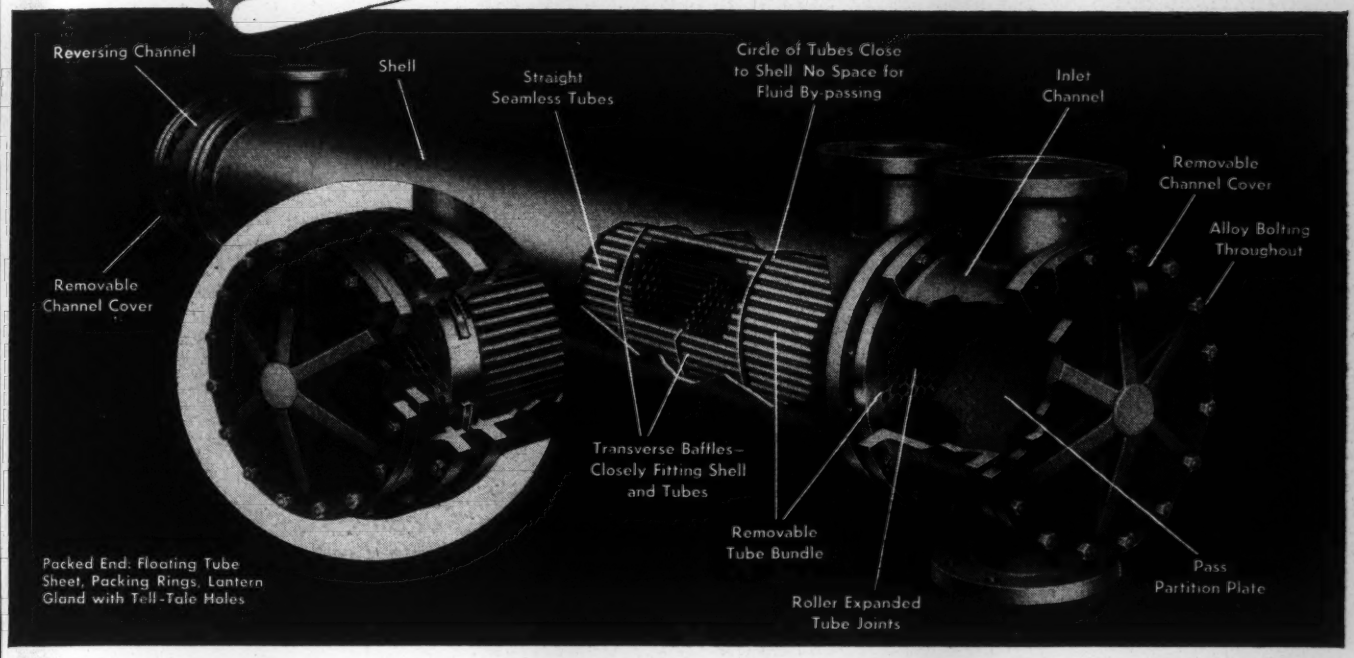
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Ross Research Reduces Size-Cost Requirements For Many Installations

For years, one of industry's most widely used, removable bundle exchangers, Ross Type CP now offers still more heat transfer capacity without increase in size.

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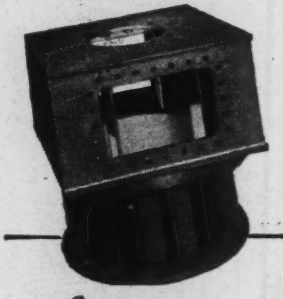

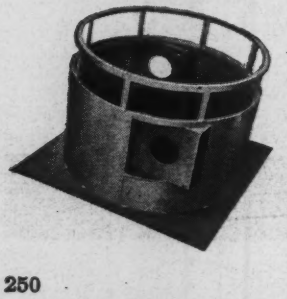

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out, 0.005-in.; spindle square to table within 0.0075-in. in 5 in. Using vertical mounted ⅓ or ½-hp, 1725-rpm motor gives four spindle speeds ranging from 740 to 4070 rpm. *South Bend Lathe Works, South Bend, Ind.*

TRANSFORMER WELDERS: Line of a-c welders in which welding heat adjustment is made electrically through an a-c/d-c reactor. No coils move and all parts are anchored in place. Main range control provides five taps, with d-c current in reactor controlled to give about 100 fine adjustments for each of main ranges. Available in 200, 300, 400 and 500 amp sizes with stationary or portable mountings. For single phase, 50 or 60 cycle, 220/440, 440/550 or 220/440/550-volt operation. *The Hobart Brothers Co., Troy, O.*

MICRO DRILLING MACHINE: For production drilling of holes as small as 0.0016-in. Only moving part is spindle, running in bronze oilless bearings of Vee type. Spindle held in position by endless rubber drive belt. Angle of drive of belt tends to pull up on drill, prevents hogging of drill into work to decrease drill breakage. *Walcon Engineering Co., New York, N. Y.*

PLASTIC PRESS: High-speed, semiautomatic, air-operated, platen type press for Plaskon alkyd resins. Adjustable to 2 sec speed if required, with controlled slowing down of platen at instant of closing. Develops 15 ton output force with 80 psi air supply. Instant reversing button supplied in control circuit. Four column model has cylinder located below platen, measures 14 by 21¾ in. between columns, with 7-in. stroke, max. *Hannifin Corp., Chicago, Ill.*

TANGENT BENDER: Four-wing bender for production of outer cases for automatic wash machines. Sheets are loaded, then clamped by center ram and two hold-down arms. Two end wings form ends of blank followed by forming of two front corners by two additional wings. Entire series of operations normally automatic, can be manually controlled. Machine requires 8⅓ by 10½ ft floor space. *The Cyril Bath Co., Cleveland, O.*

DIE CASTING MACHINE: Low-cost, completely air-operated machine. Features automatic injection, opening and closing, fast chill and high cycling speed. Capacity, 1 lb. Utilizes die block to 2½ in. thick, up to 9 by 9 in. Production speed, 600 to 800 shots per hour. Four-corner toggle lock absorbs shot pressure and gives relatively flash-free castings. In-

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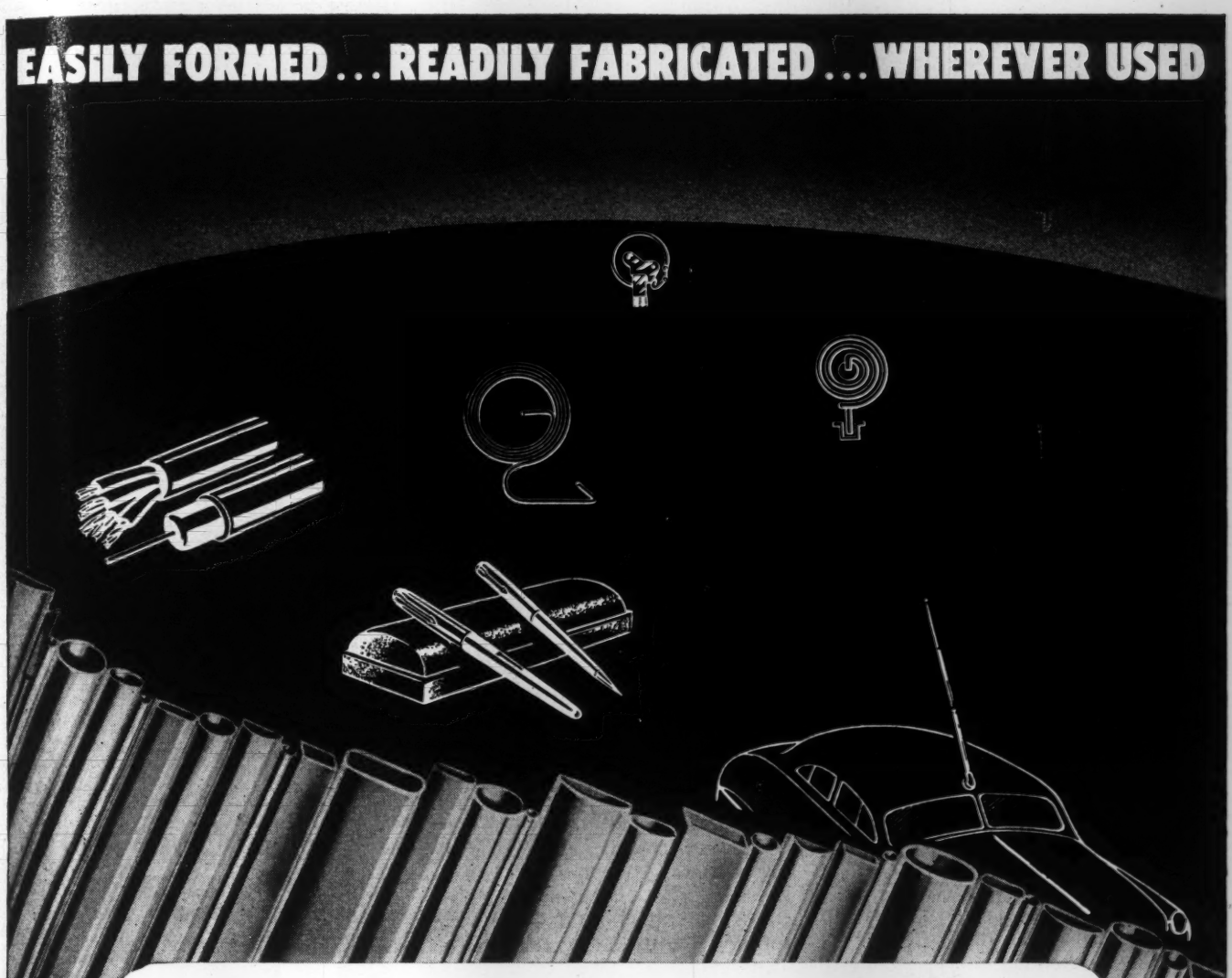

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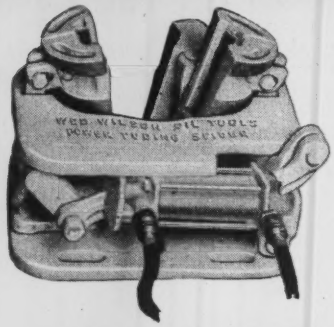

CYLINDER OPERATED OIL WELL TUBING SPIDER SAVES 40% PULLING TIME

Tubing spiders support heavy oil well tubing in the hole while tubing is being screwed together or taken apart. Three sliding wedges, or slips, jamb tubing to support it. Usual operation is by hand, inserting or removing heavy slips as needed.

New power tubing spider requires only two slips and uses a 2" diam. x 6" stroke Ledeen Heavy Duty Cylinder to actuate slips. Motion is positively controlled by foot valve. Unit saves up to 40% of pulling time, replaces extra men.

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cludes automatic part ejection. *DCMT Die Casting Machine Corp., New York, N. Y.*

LATHES: Line of engine and toolmaker's lathes in 14, 16 and 20-in. sizes. Gear box and end gearing totally enclosed. Speed changes made by sliding heavy jaw clutches. Automatic pressure lubrication to gear box, end gearing, headstock, apron, carriage bearing, and compound bottom slide. Tailstock of toolmaker's model is quick-clamping type. May be equipped with tracer duplication. *Monarch Tool Co., Sidney, O.*

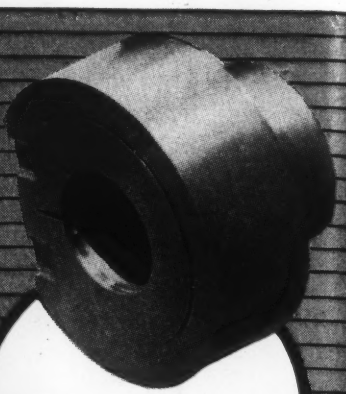
GAP GRINDING MACHINE: Sixteen-inch machine for grinding parts requiring additional swing for a large diameter of short length. Nominal swing, 16 in.; swing over gap, 40 in.; lengths, 96, 120, 144 and 168 in. Table traversed by rack and pinion, variable between 3 and 120 in. per minute. Electrical system provides automatic acceleration and deceleration at table reversal. Dead spindle headstock has No. 15 B & S taper hole in spindle. Rheostat-controlled spindle speeds variable between 20 and 72 rpm. *Cincinnati Grinders Inc., Cincinnati, O.*

AUTOMATIC FLUTE MILLER: For milling spiral or straight flutes on counterbores, taps, reamers, milling cutters, etc. Spindle housing swivels to 45 degrees for spiral fluting. Powered by 1½-hp motor through V-belts giving four speeds. Table measures 10 by 28 in., feeds from 1½ to 30 in. per minute. Indexing is automatic. Capacity: tools from ⅛ to 4-in. diameter; spacing from 2 to 40 flutes. *The Wardwell Manufacturing Co., Cleveland, O.*

SMALL PRESS: Hydraulically-operated, fast-acting unit for staking, marking, punching, riveting and press assembly. Self-contained unit powered by 1½-hp, 1800-rpm motor operating 3.3 gpm constant-volume pump. Adjustable relief valve permits setting max ram pressure between 10 and 100 per cent of rated capacity. In 1 or 2 ton sizes. Stroke, 6 in.; daylight opening, 10 in.; reach, 6 in.; and overall height above bench, 28 in. *Hannifin Corp., Chicago, Ill.*

BRUSH MAKING MACHINE: For drilling, filling and stapling brushes. Adjustable from small tooth brushes to large plater brushes. Automatically produces 200 to 340 holes and tufts per minute. Machine handles different brush shapes from flat to wide flare. *Carlson Tool and Machine Co., Geneva, Ill.*

PRESS: For die casting and other manufacturing operations requiring



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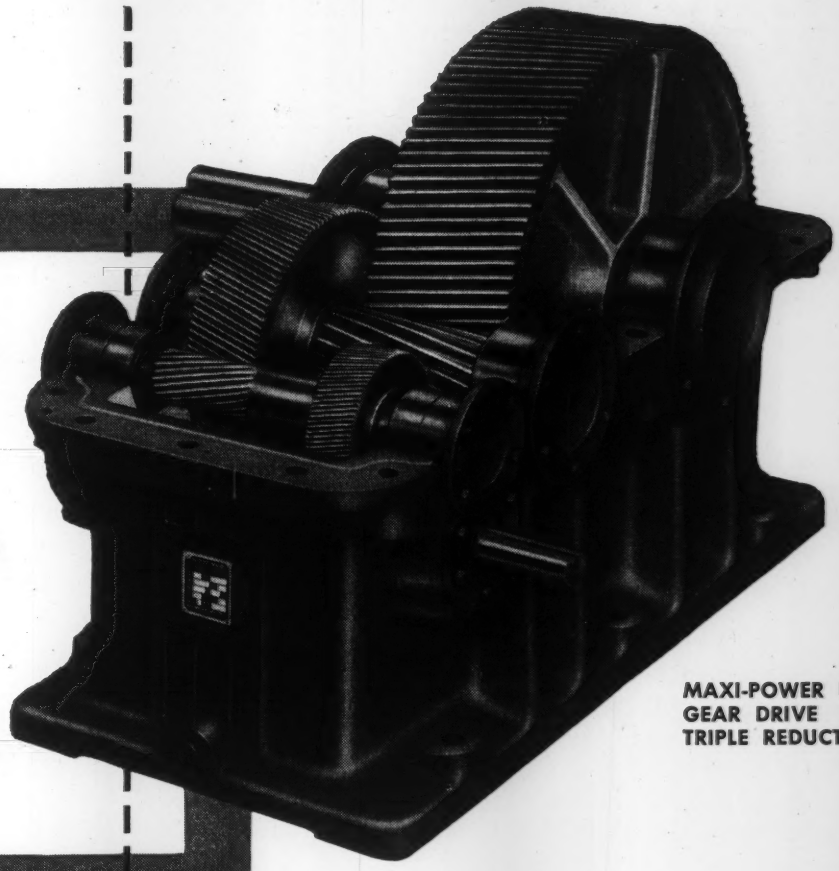

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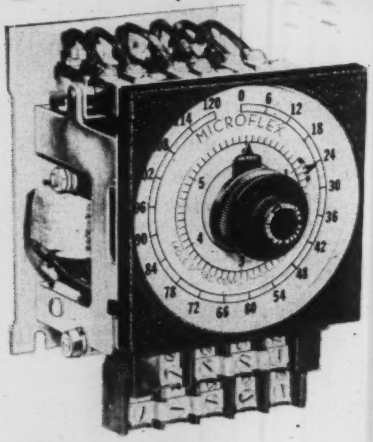
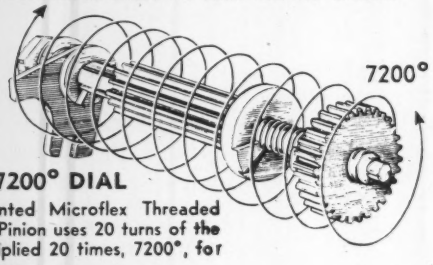


MICRO TIME SETTINGS The double Microflex Dial permits setting the timer right on the dot—like a Micrometer. One complete turn of the inner dial advances the outer dial one division.



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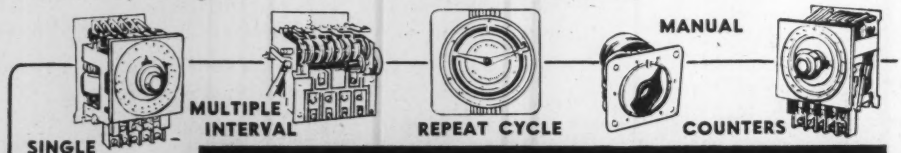

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extra stroke, shut height or throat depth. Dimensions: standard stroke, 6 in., with strokes to 12 in. available; standard shut height, 10 in. with up to 20 in. available; throat depth, 11½ in. Features removable ball seat, rear-operated reclining mechanism, nonrepeat clutch mechanism, 33 by 21-in. bed area, and 8 by 24-in. ram area. *Federal Press Co., Elkhart, Ind.*

JEWELER'S LATHE: Complete unit with motor drive and bench. Collet capacity, $\frac{3}{16}$ or $\frac{5}{16}$-in. Motor operates on 50-60 cycle, 115-v current, is equipped with reversing switch and foot operated starting switch. *Louis Levin & Son Inc., Los Angeles, Calif.*

BENDING PRESS: Capacity, 500 tons. Bends up to ⅜-in. plate 20½ ft long. Shut height with special large gooseneck punch, 30 in.; ram extension brings shut height down to 16 in. Machine has 6-in. stroke, operates at 7 or 20 strokes per minute. Clutch is air-operated, controlled by two foot-operated valves. Features large 18-in. throat. *The Cleveland Crane and Engineering Co., Wickliffe, O.*

PUNCH PRESS: For punching plates or webs of beams, channels and angles. Capacity, 200 tons or four $\frac{15}{16}$-in. diameter holes through ¾-in. plate. Stroke, 2½ in.; distance between housings, 32 in.; ram size, 28 by 13 in.; table size, 21 by 32 in.; die space, 26 in. *Beatty Machine & Mfg. Co., Hammond, Ind.*

ROLL TURNING LATHES: Two template-controlled engine lathes for contour turning steel mill rolls to 20 or 15 in. diameter. Cutting speeds, up to 100 ft per minute. Distance between centers, 132 and 96 in., respectively. Include Keller electrical contouring controls. Headstocks provide 16 speeds from 8 to 405 rpm with 1800-rpm motor. Rolls are turned on centers, permitting necks to be handled at same setup. *The Monarch Machine Tool Co., Sidney, O.*

Materials Handling

FIFTH WHEEL TRAILER: For handling heavy loads or for long hauls around docks, warehouses, etc. Includes close coupling feature that automatically links trailers 18 in. apart. Capacity, 6000 lb; width, 36 in.; length, 72 in.; height, 12¾ in.; wheel base, 30 in.; min turning radius, 62 in. *Market Forge Co., Everett, Mass.*

FORK TRUCK: Capacity, 3000 lb at 24-in. load centers. Battery powered. Features automatic acceleration accomplished through master power switch regulated by timer. Direction of travel cannot be

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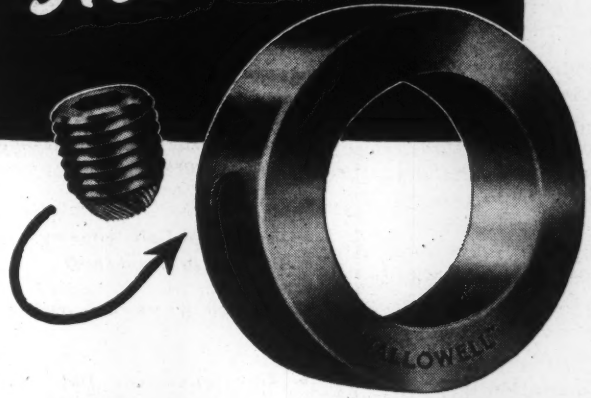

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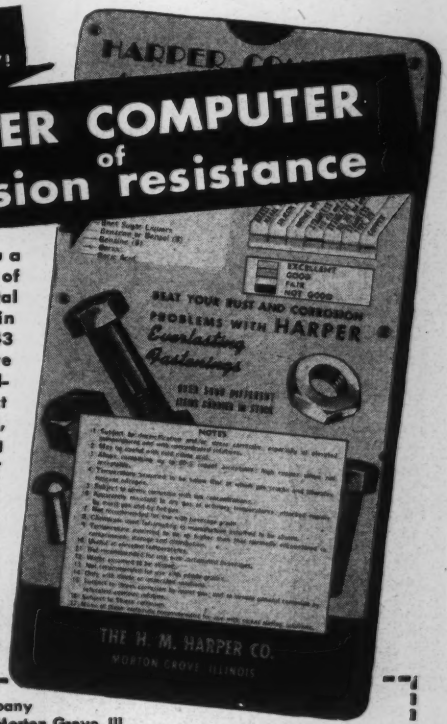

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changed until motor comes to full stop. Separate motor powers hydraulic pump for lifting and tilting. Standard lift height of 84 in. gives 61-in. overall height with forks down; lift heights available to 130 in., giving 84-in. overall with forks down. *Clark Equipment Co., Industrial Truck Div., Battle Creek, Mich.*

ELECTRIC HOIST: Capacity, 2000 lb. Controlled by pushbuttons with only 24 volts at buttons for added safety. Main frame is steel with aluminum alloy housing and end covers. Electric brake is of multiple disk type with disks operating in oil. Motor mounting receives any standard motor with NEMA flange mounting. *Shaw-Box Crane & Hoist Div., Manning, Maxwell & Moore Inc., Muskegon, Mich.*

FORK TRUCK: Lightweight models for use in limited space and floor loading capacity. Model JFTT trucks have capacities of 1000, 1500 and 2000 lb for loads 32, 40 and 48 in. long. Standard lifting heights of telescopic models, 130, 106 and 82 in. with corresponding collapsed heights of 83, 71 and 59 in. Rear wheel drive permits truck to pivot about point midway between two front wheels. *Lewis-Shepard Products Inc., Watertown, Mass.*

Plant Equipment

TRAILER SWEEPER: Three-wheel unit designed for towing by truck or tractor, powered by 15-hp Wisconsin air-cooled motor. Brush sizes available in 6, 7, 8, or 9 ft lengths, with 32-in. diameter. Overhead clearance, 4½ ft. *Little Giant Products Inc., Peoria, Ill.*

PORTABLE AIR COMPRESSORS: Hand truck or trailer models. Two-stage, air-cooled units have 30 cfm capacity at 100 psi, max operating pressure of 150 psi. Powered by hand-cranked gas engine. Compressors have patented feather valve, suction valve unloading, air maze oil bath cleaners, and standard ASME air receivers. *Worthington Pump and Machinery Corp., Harrison, N. J.*

Testing and Inspection

SHOCK TESTING MACHINE: Subjects equipment to single deceleration-time pulse. Max deceleration, 80 g; pulse duration, 0.006 to 0.032 sec. Impact delivered by dropping part secured to elevator into sand. Elevator lifted by motor driven wire, released by solenoid-actuated release. Load capacity, 150 lb; elevator dimensions, 36 by 36 by 30 in. *The Barry Corp., Cambridge, Mass.*

DEMAGNETIZER: For eliminating undesirable magnetic flux from tools.

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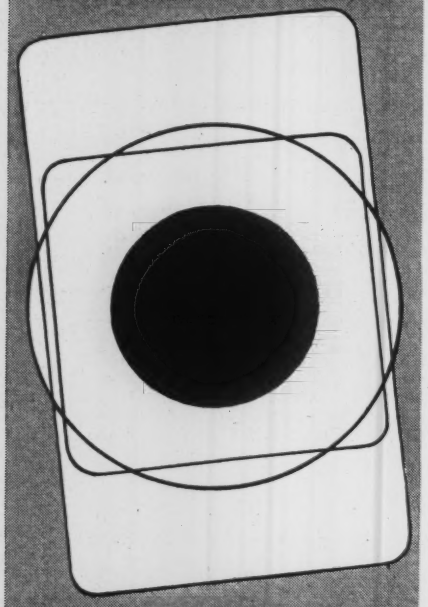
MOUNTING DIMENSIONS
— BORE FOR BORE



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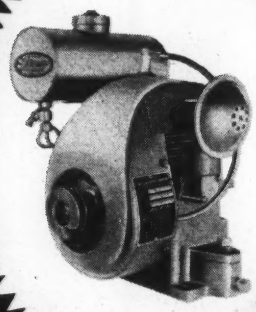

THE LAUSON Long Life ENGINE

ILLUSTRATED:
• Lauson's new bantam beauty — Model LMH. Weighs only 22 lbs.! 1 HP. Other sizes to 6 HP. All Lauson engines are 4-cycle, air-cooled!

• Insist on Lauson — the engine that's first in quality! Here are just a few of the superior construction features which make Lauson the Long-Life engine: Connecting rods have replaceable crank-pin bearing liners.

• Precision ball bearings on both ends of crankshaft.

• Fly-ball governor running in oil.

• Automotive-type float feed carburetor.

• Lauson original design provides direct stream of cool air over both valves simultaneously.

• Always choose Lauson engines — a better buy because they're better built!

The LAUSON Company
Dept. MD, New Holstein, Wisconsin
A Division of Hart-Carter Company
In Canada: Hart-Emerson Ltd., Winnipeg, Canada

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HONORABLE PAUL G. HOFFMAN
Administrator,
Economic Co-operation Administration

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